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JOINT COMMITTEE PRINT

FEDERAL MATERIALS POLICY

PART I

RECOMMENDATIONS FOR ACTION
1952–1976

With a select bibliography on
Materials Availability

PREPARED FOR THE

JOINT COMMITTEE ON DEFENSE PRODUCTION
CONGRESS OF THE UNITED STATES

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LETTER OF TRANSMITTAL

JULY 1976.

To Members of the Joint Committee on Defense Production

The occurrence of materials market disruptions and shortages in the early part of this decade, albeit short-lived, has once again drawn national attention to the dependence of American society and the American economy on the availability of raw materials. This concern has led to the establishment of the National Commission on Supplies and Shortages and to proposals for national resource information systems and for economic stockpiles to help ensure the availability of material resources for economic purposes much in the same way that the Strategic and Critical Materials Stockpile seeks to guarantee adequate supplies of materials for the national defense.

These issues are of especial interest to the Joint Committee on Defense Production, not only because of its oversight jurisdiction of the Defense Production Act, which provides authorities for the expansion of productive capacity and supply and for the National Commission on Supplies and Shortages, but also because the Defense Production Act has been proposed as the locus of authority for economic stockpiling.

In order that the Joint Committee be prepared to address the issue of economic stockpiling and the forthcoming findings and recommendations of the National Commission on Supplies and Shortages, the Congressional Research Service has been asked to provide information on past federal materials policy. The present publication, "Federal Materials Policy I: Recommendations for Action, 1952–1976," reviews a variety of solutions that have been proposed for resource availability problems over the last fifteen years. It includes a bibliography of sources on national materials policy. At a later time, the committee will publish a critical evaluation of trends in Federal materials policy, as the second in its two-part background series.

These documents together will provide a summary and an evaluation of Federal materials policy that has never before been compiled. As such, they will be of considerable use and interest to you, to other Members of Congress, and to the public at large.

LEONOR K. (Mrs. John B.) SULLIVAN,
Chairman.

EDITORIAL NOTE

At the request of the Subcommittee on Materials Availability of the Joint Committee on Defense Production, the Science Policy Research Division of the Congressional Research Service has prepared a compendium of summaries of the major points in selected Federal materials policy documents. The time period from 1952 to early 1976 has been covered in this analysis. This report consists of eighteen separate summaries prepared, as noted, by the following analysts in Science and Technology/Physical Sciences: Ms. Carol Lee McBee, Mr. William Boesman, Mr. Paul Rothberg and Ms. Elaine C. Carlson and by Mr. L. Harold Bullis, Specialist in Science and Technology. For completeness, we have also included an analysis of a materials policy report prepared earlier by Dr. Franklin C. Huddle, Senior Specialist in Science and Technology, for the U.S. House of Representatives, Committee on Science and Technology.

The documents have been arranged in chronological order for this report. Those which have been included were selected on the basis of their potential impact and importance to future Federal materials policy statements. Due to the amount of material involved, the recommendations, major points and arguments in each document have been considerably abbreviated. Full bibliographic citations to the covered documents appear as footnotes to each title. For your convenience, the individual analysts have provided, in most cases, an introductory summary, which gives the major emphasis of each document and the most important recommendation(s) evolving from each.

The bibliography on materials availability was prepared by Mr. William Boesman, with assistance from other CRS staff members, according to the instructions of the subcommittee.

This report is intended to provide the members of Congress with an easily accessible guide to the materials policy statements made by the executive branch and the Congress, and to summarize the advice and commentary that has been received by these two bodies in the past concerning materials policy.

CONTENTS

I. RESOURCES FOR FREEDOM

SUMMARY OF THE REPORT TO THE PRESIDENT BY THE PRESIDENT'S MATERIALS POLICY COMMISSION (PALEY) JUNE 1952 [1]

The very title of this document, "Resources for Freedom", reflects the tenor of the times in which the Paley Commission functioned. The United States had just recovered from the materials drain of World War II and the Korean conflict was not yet a thing of the past. The drain on the materials resources of the Nation was painfully evident, as was the apparent lack of an established policy for dealing effectively with such wartime demands. As a first task, the Commission attempted to define the probable materials shortages using the coming 20–25 year period as their base. They naturally had to make numerous assumptions in order to project the future materials needs of the United States. Some of these included: the assumption that the relative prices of various minerals would remain essentially constant through 1975; that the GNP of the United States would double over what it was in 1950, but that the increase in the total materials stream needed to accomplish this would be only 50–60 percent; that the population of the United States would be 193 million by 1975; that the question of "war or no war" was irrelevant since the materials problem would not vanish, even in the event of complete peace and prosperity; and that no allowances for dramatic technological breakthroughs, unusual and unpredictable substitutions, or substantive changes in materials usage patterns would be made. The Commission was also guided by a number of prevalent beliefs in making their analysis: that the threat of Communism was real, barbaric and potentially violent and that military security, based on a strong investment in materials, would be one of the major factors in the defeat of this force; that the private enterprise system was the most efficacious way of performing industrial tasks in the United States; that the destinies of the United States and the rest of the free world were inextricably bound together; that a self-sufficiency posture would be untenable as a national materials policy since it would cost too much; and that our responsibility to the next generation did not require that we "save" resources, since such a policy did not take into account technological advances which might give a subsequent generation better and more efficient use of available materials than we have.

The Commission viewed the following categories as the major "materials" to be considered in their report; minerals, timber, agricultural products, industrial water, and energy. Based on their assumptions and beliefs, they made the following projections as to the demands for these materials by the year 1975: for minerals, the demand would be 90 percent higher than in 1950; for timber the increase in demand

[1] The President's Materials Policy Commission (The Paley Commission). Resources for Freedom. Washington, U.S. Government Printing Office, 1952. (5 vol.). 819 p.

over 1950 levels would be about 10 percent; a 40 percent increase in demand for agricultural products would be evident; industrial water needs might rise by 170 percent; and the total energy demands would probably double over those of 1950.

The central focus of the Commission was to consider the costs of materials . . . in terms of purchase price, capital investment for production, hours of human efforts for extraction or processing, units of energy for mining, manufacturing, and processing. The Commission felt that these were real costs, and that the Nation should carefully consider the costs involved, especially in terms of the investment of energy and available industrial water, before it launched any further into a "Buy American" strategy. In fact, the Commission suggested that there was only one real solution to the looming materials problem, and that was to assume a much more flexible posture in terms of our policy for materials acquirement. That is, they suggested moving on three fronts to assure an adequate supply of resources for this Nation:

> We can get more materials and more energy from domestic resources by pushing back the technologicial, physical and economic boundaries that presently limit the supply.
>
> We can alter our patterns of materials use by more efficient designs and processes—and by shifting the burden of use away from scarcer materials, toward more abundant ones.
>
> We can get more materials from abroad, on terms beneficial to ourselves and other free nations.

If any one policy was advocated in the Commission's report, it was that no matter where, how, or from whom we obtain our materials, we should consistently aim to make such acquisitions at the least cost to us. Cost, in their context, meant all of the associated real costs involved in materials acquisition and processing, as discussed previously. They felt that uncertainty about the future was the source of greatest difficulty in formulating a national materials policy, and expressed the idea that any such formulation would essentially act as a huge insurance policy to protect the Nation against such contingencies as defeat in war or the collapse of our standard of living.

The recommendations of the Commission perhaps lacked in specificity, consisting mainly of statements about what should be done, with no real suggestions about how or who. Since this was, however, one of the first comprehensive treatments of materials policy for the Nation, it might be said that such a lack of detail would not have been considered detrimental at the time. The recommendations seemed to be keyed mainly to two major thoughts: first, that U.S. policy makers did not then know enough about materials in general, and specifically that it was not really known what was available or how materials could be used to best advantage; second, that no matter what the preferences of the United States might be, it would be essentially impossible to be materials-self-sufficient, so that any policy statements should reflect a means to deal effectively with other nations in order to meet future resource requirements.

* * * * * * *

The Paley Commission, in their report of June 1952, selected five major categories of materials to be considered in their assessment. The

major recommendations of the Commission in each of these areas included:

MINERALS

More information; access to public lands; incentives for exploration

That the Department of Interior should strengthen its programs for gathering and analyzing basic facts about minerals; that a complete census of mineral industries be taken in 1954 and every five years thereafter.

That the U.S. Geological Survey accelerate the mapping of the United States and Alaska; that a program to coordinate (drill) core samples be developed; that the NSF lead an intensive program of basic research on methods of exploration for minerals.

That, in view of the fact that many geologists believed that undiscovered mineral deposits were under land belonging to the Federal Government, the leasing system should be made more available for the mining of such deposits, and that the location system should be subjected to several reforms.

That percentage depletion be retained as a tax device, with no further raise in the rates; and that limitations on the expending of exploration costs for minerals other than oil and gas be removed.

TIMBER

More protection; better management; more accessibility

That the Federal contribution to the program of fire protection for forests be increased; that a nationwide program of pest control be developed by the Bureau of Entomology and Plant Quarantine; that forest research be intensified.

That good timber management practices on the part of private woodland owners be encouraged by increasing technical assistance; that the compulsory regulations of destructive timber cutting on private land by States be watched closely and augmented if necessary by the Federal Government.

That access roads to the timber available in the National Forests be built; that planting programs in the Federal forests be intensified.

ENERGY

Continuance of imports; underground "stockpiles"; oil from shale; natural energy should not be wasted; coal gasification, hydropower, and nuclear power should be developed; materials and energy policies should be coordinated

That present knowledge of our oil needs and available resources would not warrant discrimination against imports of crude oil from any quarter of the world; that tariffs on crude oil imports should be held down, reduced, or eliminated; that encouragement should be given to establishing greater oil reserves in "safe" areas.

That the possibility of war necessitates the existence of an emergency cushion of oil which could best be met by having an "underground stockpile" of semiproved oil deposits; that the exploration of the Continental Shelf, particularly off the Gulf

Coast, would provide the most likely means of reaching this objective; that any private leases should require provisions to prolong the life of such oil pools.

That the government provide limited financial help to private enterprises willing to undertake the production of oil from shale, and that the National Security Resources Board study the economic aspects of producing synthetic liquid fuels from shale and from coal.

That major losses of natural gas seemingly occurred from inadequate procedures at the field to prevent "flaring" and therefore conservation measures should be encouraged.

That much natural gas is wasted in inefficient uses, and consumption patterns should be shifted toward special advantage users. They did not, however, recommend detailed regulatory procedures to accomplish this end.

That since coal reserves had been mined in the United States only by about 2.5 percent and thus provided the greatest hope for future energy needs, the experimental work of the Bureau of Mines in underground gasification merited strong support.

That a strong program be undertaken to advance coal technology, specifically to: improve the man-hour output, improve mechanization and continuous-mining methods; develop cheaper ways to transport coal; and further examine methods to improve coal utilization (for example, increases in thermal efficiency in electricity generation).

That since water power is the one major source of electricity that does not cause a drain on mineral fuel resources, the Commission recommended that hydroelectric potential should be developed rapidly; that the St. Lawrence, Niagara and Columbia River areas should be the subject of early action.

That power production from nuclear fuels could be a valuable supplement to other sources of energy, so that AEC and private utilities should continue their cooperative arrangements to develop means to use atomic sources.

That an appropriate Federal agency should be established to undertake a continuing broad appraisal of the Nation's long-range energy outlook; that any such program should be closely coordinated with efforts in the formation of policy for all materials.

AGRICULTURAL PRODUCTS

Better farm management; flexibility in price supports; more research

Although the Commission recognized that many farm products weighed heavily in the materials outlook for the Nation (cotton, wool, fats, oils, industrial alcohol, etc.), they made it clear that they "undertook no detailed study of agriculture * * * [and had] * * * no specific recommendations." The report did offer four suggestions in regard to farm policy, however:

That the government could help farmers develop comprehensive, long-range plans for efficient management of their farms, which could significantly raise output.

That specialized types of credit for land improvement, livestock, equipment, and buildings would be needed by farmers.

That a more flexible price support system, responsive to sudden market swings and so forth, could contribute to more efficient use of land.

That technical research programs in agriculture should be continued, and that long-range economic research programs should be expanded.

INDUSTRIAL WATER

Users should pay; pollution should be abated; water supply characteristics should be studied

The Commission recognized the importance of water in the production and processing of materials, and noted that the rising importance of the chemical industry would probably increase the demand for water of high quality by 1975. They noted that they did not undertake any new study of water, since that task had recently been performed by the President's Water Resources Policy Commission. No recommendations were given in this report, therefore, but the Commission did include some of the general conclusions relating to industrial water from the previous Commission's report:

That water development projects should be multi-purpose: that there should be a general national policy for such development: that direct beneficiaries of water development projects should be identified and help pay for the projects: that where water is scarce, it should be put to its best economic use.

That the government should continue its basic studies of rainfall, run-off, percolation, and other factors in the water supply.

That separate water development programs of the Federal Government should be better integrated.

That Federal participation in pollution abatement should be continued and intensified.

The Commission also expressed one belief concerning water pollution:

That the Water Pollution Control Act should be continued, with certain revisions with regard to construction loans and engineering grants to make them more workable: that provisions embodied in the legislation allowing long preliminaries prior to Federal enforcement action against industrial pollution should be given a trial but probably would not bring the situation under control; that a tax on polluters of navigable waters and interstate streams could be an alternative control system.

TECHNOLOGY AND MATERIALS POLICY

The Commission next examined the role of technology in the Nation's materials policy. It noted that the enormous growth of technology during the 20th century "has had two opposite effects on materials: it has greatly increased the efficiency of their use, and it has also greatly increased the total drain upon the resources from which they come." The Commission felt that the materials problem did not require any output of "high scientific difficulty" to overcome, however. It was the concensus of the Commission that most of the technology was available to synthesize or substitute materials at will. For instance, it was mentioned that gasoline currently could be produced from coal,

cattle feed from sawdust, and commercial power from atomic fission. The problems did not stem from the inadequacies of science, but from the questions of economics; the products could be produced, but at a very dear price. The report of the Commission did note, however, that certain areas of potential benefit in the materials research area were sadly lacking in effort on the part of both industry and the government.

Specifically, the Commission felt that materials technology should address six important tasks in the years ahead:

> To foster new techniques for discovery . . . great ore bodies were believed to lie below the earth's surface.
>
> To bring into use materials which so far had evaded utilization efforts . . . industry had learned thus far to use only a fraction of the elements and substances known.
>
> To apply the principle of recycling more and more broadly.
>
> To learn how to deal with low concentrations of useful materials . . . industries would have to develop techniques to extract the sought-for minerals from materials containing much less percentage of that mineral than in current practice.
>
> To develop and use more economically the resources that nature can renew . . . solar energy was the focus here, since stockpiles of fossil fuel not only took millions of years to accumulate, but were exhaustible as well.
>
> To lessen or eliminate the need for a scarce material by substituting a more abundant one . . . a broad view was taken here: Consider not only the substitution, say, of aluminum for copper in wires, but the possible substitution of microwaves for wires.

RESEARCH NEEDS FOR MATERIALS

Having defined the future technological developments required to abate the materials problem the Commission turned to the consideration of who should conduct the research, who should pay for it, and whether the Nation had sufficient manpower to accomplish the task. It was noted that industry carried 41 percent of the research effort in the United States, with most of this concentrated in four major industries: chemicals, communications, petroleum and coal products, and aircraft. Universities accounted for only 10 percent of the research effort, but seven percent of that was actually paid for by industry and the government. The Federal Government held the lion's share of the research effort, but the Commission noted that probably 90 percent of that was primarily concerned in 1952 with weapons and equipment of war.

Although two-thirds of the total science population engaged in research were physical scientists (chemists, metallurgists, physicists), only four percent were earth scientists (geologists and geophysicists), a fact which the Commission believed contributed to the Nation's lag in metallic ore exploration efforts. The report mentioned that the U.S. Selective Service could play a major role in removing needed materials scientists from the research mainstream. Although the Commission did not wish to make any specific recommendations on this

subject, it did think that continued studies of deferral policies would be needed since basic research and technological improvements were considered fundamental to solving the materials problem.

In view of the concentration of research efforts in the Federal Government, the Commission felt that the apparent lack of coherent policy direction, especially with regard to materials, was a major problem.

It was suggested that the legislative mandate for the National Science Foundation was broad enough to allow its evolution into a top policy coordinating instrumentality, "if and when practical circumstances permit." The Commission questioned why the budget for the NSF had been set so low ($3.5 million) when a $15 million ceiling had been stipulated by law. (Actually, the Bush [2] report, which initiated the idea of a national science foundation, had called for minimum support of $33.5 million in the first year, and by the fifth year, an annual budget of $122.5 million.[3])

The Commission recommended therefore:

> That the appropriations of the NSF be increased to ceiling, and that the Congress re-examine its reasons for setting this limit so low.

The Commission expressed concern that no one federal agency was in charge of the coordination of materials technology. It was felt that an active governmental body was essential to:

> Revise on a continuing basis estimates of reserves;
>
> Project annually requirements on supplies at least ten years into the future; and to report potential shortages of important materials in time to allow for corrective action;
>
> To maintain a list of materials R. & D. projects that should be undertaken; and to assure that the government is informed when industry does not take up such projects.

MATERIALS ABROAD

Most of the preceding statements and recommendations had dealt with the potentials for gaining more efficient use of the materials resources currently available at home. The Commission felt strongly that the United States must also cultivate appropriate sources abroad in order to adequately meet our materials' needs. It was predicted by the Commission that by 1975, the United States would probably be able to produce 75 to 85 percent of its increased resource needs and would rely on imports for the rest. The trend for other nations would be the same, if not accentuated, so that competition for foreign resources would be a major factor. The Commission felt the Nation must realize that developing countries were becoming acutely aware of the disparities in living standards between industrialized nations who wanted the resources, and the supplying nations, who were often just floundering onto the technological frontier. It felt that the United States must be prepared to return service-in-kind, that is, aid to such nations in order to raise their standards of living, if cooperation were

[2] Bush, Vannevar. Science—The Endless Frontier, Washington, D.C. National Science Foundation publication 60–40, [1960] 220 p.
[3] Bush, Vannevar, ibid., p. 40

to be achieved. Specific recommendations were made on this and three other areas in regards to the acquisition of materials from abroad:

AIDING RESOURCE COUNTRIES

Assistance for development; U.N. technical assistance

That public loans and technical assistance would be needed to aid other countries, where the people of these areas desire, in diversification of economic development and improved ability to expand materials production for export.

That the United States should encourage wider use of United Nations technical assistance in geological surveying and minerals exploration in underdeveloped countries; that the United States should expand its own programs in this area.

STIMULATING PRIVATE ENTERPRISE

Protecting investor's rights; incentives for investment

That, in view of the fact that foreign investors take a high risk in developing materials resources in developing, and sometimes politically unstable, countries, the United States should extend its diplomatic efforts to create a more favorable basis for bargaining and the conclusion of agreements between investors and the resource country governments; that the negotiation of government-to-government special resource treaties should be pursued to stimulate investors previously detained by legal and administrative deterrents.

That certain changes in the U.S. tax laws be initiated, including permitting deferral of reporting income until actually received; and extension of the privilege of filing consolidated returns with foreign subsidiaries.

INVESTMENT IN SECURITY

The Commission noted that the United States may need stand-by materials capacity for security reasons, the development of which private investors may reject as too risky or financially unattractive. Therefore they recommended:

That a permanent agency be established with power to make long-term purchase arrangements for foreign-produced materials, including price guarantees; to make loans for foreign materials production; and to enter into management contracts for foreign materials expansion.

REMOVING BARRIERS TO TRADE

The Commission felt that the "overriding national interest points clearly to the desirability of eliminating * * * obsolete barriers to the entry of materials in this country," and recommended:

That permanent legislation empowering the elimination of duty be enacted when the need for imports of particular materials becomes crucial.

That in view of the fact that the Buy America Act interfered with the rapid and economic building of the strategic stockpile and encouraged more rapid depletion of U.S. resources, it, and similar provisions, should be repealed.

INTERNATIONAL ACTION

In the area of world trade, the Commission expressed the opinion that the United States, by virtue of its position, had a responsibility for seeking greater international efforts to unchoke the channels of trade. It suggested that a continuing survey of world materials demand and of the adequacy of existing and planned production to meet it was needed, and recommended:

That the United Nations compile such statistics and, when needed, set up special international study groups to review special problems relating to particular materials as they arise.

REDUCING MARKET INSTABILITY

One of the strongest factors mentioned by the Commission as affecting the rates of production, volume of investment, and the economies of both the producing and consuming nations in regard to materials was the erratic behavior of the materials market. It was noted that in the first half of the 20th century, resource countries encountered an average annual price variation of 18 percent in 14 commodities. Therefore the Commission proposed:

That efforts to reduce market instabilities should be instituted including: multilateral commodity agreements to assure producers a market at an agreed minimum price and consumers a supply at an agreed maximum price; and the testing of the use of international buffer stocks which would act as a residual buyer or seller. (When prices for selected materials rose or fell, the buffer could be used to confine the actual prices to a moderate range.)

NATIONAL SECURITY AND MATERIALS

The final topic addressed by the Commission was that of security and the military's demand for materials in both war and peacetime. The Commission recognized the realities of a possible world war, in which the United States may not have the time to mobilize resources, as they have in the past. The implication was that "a quick military buildup would be possible only if the United States had materials strength-in-being." This could be accomplished in two ways in their view: having the ability to quickly divert materials from civilian to military production, and having ample stockpiles to supplement available materials as needed, or to replace sources cut off during the war. The Commission suggested that the military could contribute to a relief in the materials demand by adopting more conservative policies and practices in their operations. For instance, the Commission proposed that the military could tailor the quota of materials to the minimum needed in both a hot and cold war situation; that military specifications could focus on using abundant rather than scarce materials for

military products; that more emphasis on care and maintenance of equipment was indicated; that "stand-by" designs should be available which would substitute available materials for those cut off by a war.

To increase the supply of materials for security reasons, the following actions were suggested: promote accelerated growth of materials production, as part of a preparedness program; stockpile strategic and critical materials; set up emergency stand-by facilities for emergency production; establish domestic in-ground reserves of key materials by limiting extraction; promote the discovery and development of reserves in safe areas abroad; accelerate the development of new production techniques.

Even in a time of war, the Commission did not feel that the United States could reasonably expect to be materials self-sufficient. It felt that the basic policy of seeking lowest cost sources of materials could not be neglected even during a war. The Commission indicated that the burden of much of the possible reduction in security-demand materials rested with the military establishment itself. In reference to this, the report stated that "shrinking of total military materials requirements on a unit basis should begin with estimating needs, enter consciously into planning of specifications and designs, and continue at every possible step. The armed forces should use substitution, redesign, research, and conservation to stretch materials, without sacrificing the efficacy of armaments." The Commission further recommended:

> That the Research and Development Board of the DOD give pointed and continuing attention to finding ways by which the military establishment can make more efficient use of materials and thereby contribute to improving the Nation's general materials position.

STOCKPILES

In spite of the obvious advantage, for security reasons, of the establishment of adequate stockpiles of strategic and critical materials, the Commission noted the efforts to meet quotas to date had been less than enthusiastic. In fact, it was stated that as of March 1952 the total stockpile was only one-third full, despite the fact that stockpiling as a public policy began in 1939, and the legislation in effect had been enacted in 1946.

Therefore the Commission made the following recommendations:

> That stockpiling of strategic materials be made a permanent instrument of the national materials policy of the United States and that adequate funds be provided.
>
> That vulnerability to enemy attack of facilities for producing materials within the United States and other Western Hemisphere countries be fully evaluated in estimating stockpile objectives.
>
> That annual reviews of objectives should take place, including consideration of the effects of stockpiling on the U.S. economy, and possible alternative plans.
>
> That acquisitions should be made at a minimum cost, including repeal of the Buy American provisions in the existing Stockpiling Act.
>
> That no withdrawals be authorized except in a declared emergency.

RESERVE PRODUCTION CUSHION

The Commission suggested that three devices could be utilized to establish such a cushion which could be tapped in wartime. Setting aside in-the-ground mineral reserves within the United States and its territories with the appropriate contingency plans to bring such stockpiles into speedy production; development of technology which could be applied to below-grade ores which would, in ordinary times, not be economically feasible to use; development of additional sources of "safe" foreign supply. In addition, the Commission made a case for the development of the St. Lawrence Seaway, which could be used to ship iron ore from Labrador and could also provide more safety for such shipments from the possibility of submarine attacks. It was therefore recommended:

> That the development of the St. Lawrence Seaway be initiated in the near future for transportation purposes.

INFORMATION COORDINATION

The Commission saw, as a continuing task, the necessity of improving our information base in regards to materials technology, availability, policy, and programs. It indicated that the Federal Government was "not at present properly equipped to carry out its responsibilities for dealing single-mindedly with the many aspects of the materials problem," that the "whole effort lacks sufficient coordination." To deal better with the lack of coordination of materials information, the Commission recommended:

> That each agency concerned with primary data on materials strengthen its own fact-gathering, analytical, and programming machinery so that total efforts by the government would be adequate to meet the needs.

The other major difficulty with our materials posture, the lack of a coordinating body which could deal in a comprehensive manner with the needs of the Nation, prompted the Commission to make its final recommendation:

> That the National Security Resources Board be strengthened and adequately financed so that it could collect in one place facts, analyses, and program plans of all agencies on materials and energy problems and related technological and special security problems; that they should evaluate materials programs and policies in all these fields and recommend appropriate action to the President, Congress, and executive agencies.

The Commission was convinced that a continuing forward audit of the materials field was essential and that an executive-level agency was needed to accomplish this task. They thought such an organization could serve the country well by keeping government, business, and the general public informed of leading developments in all the related materials fields. The report emphasized that "improving the various parts of government equipment for dealing with materials problems will not make the whole operation run as it should," that only the establishment of a mechanism for looking at the subject as a whole could effectively deal with the indivisible materials problem.

—Summary by Carol Lee McBee.

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II. PROBLEMS AND ISSUES OF A NATIONAL MATERIALS POLICY

Summary of the Papers Delivered at the Engineering Foundation Research Conference on National Materials, July 1970[1]

This first "Henniker" conference was organized with the encouragement of Senator J. Caleb Boggs, and the proceedings appeared as a committee print for the Committee on Public Works of the United States Senate, December 1970. The stated purpose of the conference, at which only invited papers were given, was "to explore the need for a continuing national mechanism in the government to recommend, determine, and, as necessary, coordinate policy in the spectrum of issues involving materials."

It was noted in the preface to the report, that in retrospect, the participants felt that certain "impressions" could be drawn from the papers, exchanges and so forth during the conference. These included:

The opinion that serious problems could be foreseen in future supplies of materials and quantities of energy to meet national needs;

The perception that there was a close interaction between materials, fuel, and energy on the one hand, and environmental quality on the other;

A concern for the tendency that seemed to be apparent in the Nation to deal emotionally with difficult technical issues;

An anxiety over the prospects of a shortage of talented and trained people to meet future needs in the management of materials; and

The belief that the longer-range future, with regard to materials problems was receiving insufficient attention.

* * * * * * *

The first "Henniker" conference held in 1970, was not intended to be a body formed to adopt resolutions or make recommendations, although some of the speakers did present their personal views on possible measures or steps which should be taken with regards to national materials policy.

Papers were presented in these general subject areas: General Policy; Problems of Materials Supply; Materials as Wastes-Wastes as Materials; Energy, Fuels, and Environment; Technical Aspects of Materials; and Organizations as Sources of Policy Advice.

What follows is a very brief summarization of each paper presented at the conference. Where specific suggestions or recommendations have been made they are duly noted. However, it must be emphasized that such recommendations did not necessarily carry the "approval" of the entire body of attendees.

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[1] Henniker I: U.S. Congress. Senate. Committee on Public Works. Problems and issues of a national materials policy. Committee Print, 91st Congress, 2d session. Washington, U.S. Government Printing Office, 1970. 272 p.

GENERAL POLICY

Franklin P. Huddle, of the Legislative Reference Service, Library of Congress, in his opening remarks to the conference, noted that the purpose of the meeting was to "sharpen the understanding of the materials community and public policymakers as to the nature, the scope, and the issues of national materials policy." He felt that the subject of materials policy was receiving a great deal of current attention from legislators, especially in view of the possible passage of the National Materials Policy Act of 1970, which would instruct the President to appoint a Commission on National Materials Policy. Huddle also defined the scope of the term "materials" for the conference, i.e. to include substances processed or consumed by industry. To set the context for the conference. he addressed the importance of materials to the Nation, stating that "materials are essential ingredients of all our consumer products. Without proper management of our resources of materials, all our industry and all the elaborate economic pyramid we have built on industry, and all our political and social and military programs, would collapse together."

The fact that there were defects in the system of materials management, as it exists, was fully recognized. He indicated that the full array of costs and consequences involved with materials usage had not been adequately weighed. Huddle thought that the real issue was how to constructively mobilize the current public anxiety over the deterioration of the environment to achieve the needed corrections within the democratic system. He also noted that other issues should be addressed during the course of the conference including: the alernatives available for control of mounting wastes; the conflicting policies in materials management; the relation of research on materials to the public needs and wants; the priorities in R. & D., especially in the face of declining budgets; the weighing of the claims of the present against the rights of the future; and the prospects of bringing together the technological community and the humanistic part of our society.

The keynote address was made by **Senator J. Caleb Boggs,** who noted that in the work of the Senate Public Works Committee materials were now defined "as any natural resource, whether animal, vegetable, or mineral, that is intended to be utilized by industry for the production of goods, with the exclusion of foodstuffs." He further stated that the Commission under discussion in the current Congress was part of the solid waste pollution legislation, which he thought was appropriate since "materials and their processing are quite obviously the source of pollution." Senator Boggs went on to elaborate on some of the major provisions of the National Materials Policy Act and the specific charges to the Commission. He referenced an earlier report of the Senate Committee on Public Works, "Towards a National Materials Policy", which suggested the urgency of establishing a Commission on National Materials Policy which would have the following objectives:

> Identify the relationship of materials in all their aspects to national goals and objectives;
>
> Define materials goals and objectives of the Nation;

Contribute to a broader understanding of materials problems and opportunities; and

Maximize, as far as possible, the opportunities for free enterprise to function efficiently in the materials field.

James Boyd, of the Copper Range Co., presented a review of the history of minerals policy in the United States. He noted that some involved in mineral affairs had consistently claimed there was no such thing as a national policy, however, he had always held the view that a collection of laws and legislative actions existed which constituted a policy. Upon researching for this paper, however, he became convinced that this was not the case at all. The first specific legislative statement impacting on materials that he mentioned was the Stockpiling Act of 1941, the objective of which was to "decrease and prevent wherever possible a dangerous and costly dependence of the United States upon foreign nations for supplies * * *." The 1952 report of the Paley Commission, however, stated that "The overall objective of a national materials policy for the United States should be to insure an adequate and dependable flow of materials at the lowest cost consistent with national security and with the welfare of friendly nations." The language of the Stockpiling Act was ultimately extended so that the purchase and sale of stockpile materials could be used to solve temporary economic conditions, while the recommendations of the Paley Commission were largely ignored. He felt that materials policy statements were often subjected to such treatments. Boyd then backed up a bit, and reviewed the historical developments in the United States which may have contributed to our national attitudes toward minerals and any policies dealing with them. He noted that early settlers in this country needed materials from the outside in order to build industries so that the needs for legislation were limited. As industry grew and mineral resources became the source of wealth for individuals as well as input to the budding industries, it served the national interest to provide incentives to search for such minerals by granting privileges of land ownership to those willing to take the risks. There came a time, however, when the demands of industry for raw materials came into conflict with other uses of the land, so that certain laws materialized to regulate the search for and mining of minerals. Then came a succession of major wars, which taxed the supply of materials of all sorts and the national goal was to distribute the limited amount of raw materials available to sustain a minimum civilian economy in order to develop a superior military force. Thus, temporary laws were passed to permit the control and distribution of raw materials. However, such laws tended to foster attitudes towards the development and control of materials which continued into periods of normal economic activity. Boyd felt that it was "because of these conditions that the cry for a national minerals policy has been raised * * *."

He noted that certain Federal actions in the past decades had contributed significantly to tight controls on the minerals resources of the United States. Some of these included the establishment of the wilderness system, institution of certain safety laws in coal mines which may result in loss of coal to a fuel-starved economy, and the in-

stitution of strict controls on the quality of water and air resources. He did not argue whether these actions had been right or wrong, but merely pointed out that actions taken to reach one goal may very often interfere with the means for reaching others, so that policies are very often in conflict.

He closed with the mention of an oft-repeated historical mistake . . . that of creating commissions to make recommendations on materials policy but not making sufficient provision to bring the recommendations contained in such surveys to fruition.

William J. Harris, of the Association of American Railroads, in his presentation, stated that "Environmental control in the United States is fundamentally dependent on effective management of materials." He noted that products, and all the processes they must undergo to attain their final form, as well as their ultimate disposal after use, to a large extent create the pollution problem. He felt that the regulatory process to control products due to this fact, however, should not be overly relied upon until some determination was made of the economic consequences of such constraints. He said, "The policy issue does not argue against conservation. It does suggest that there are limits on the extent to which the environment can be preserved." Harris indicated that national goals usually direct the major emphasis in the materials research and education field. In the past, when national defense was the major concern, research efforts in the materials area centered on this topic. He noted that now, as national priorities change, "governmental programs are being launched to generate new ideas and concepts directed toward the relation of materials programs to the environment." His major point was, however, that a "substantial increase in educational and research support will be necessary to counteract the years of emphasis on high performance materials * * *."

Packaging and container development which provide long shelf-life were singled out by Harris as having led to solid waste problems of enormous complexity. He noted that ultimately "the economy will demand more recycling of materials as a requirement for survival" and felt that the potential for recycling must be given immediate priority.

The needs of a variety of Federal agencies for materials were addressed by **Cyrus Klingsberg,** appearing for the National Academy of Sciences. He stated that most of the active materials people he knew were associated with atomic energy, defense or space. This seemed to be a major problem, since many other mission agencies had special materials needs which remained unrecognized, or were not assigned a high enough priority to allow the launching of efforts of their own in materials development. Klingsberg cautioned that other agencies should not rely solely on DOD, NASA and AEC to do their research for them since "solutions 'off the shelf' from defense-space research will not always suffice for the newer problems." He went on to enumerate the materials research needs in three selected agencies: HUD, DOT and HEW. Briefly, he suggested that HUD needed new materials or composites that would lend themselves to use in low-cost housing and/or required less maintenance. DOT's needs would be centered

around efforts to provide high-speed ground transportation systems. Specifically, materials for more efficient braking systems, structural materials for high pay-load-to-weight ratios, and materials more resistant to corrosion, friction and wear would be needed. HEW would require new biomaterials which could work with and support the skeleton, the heart and various body functions.

He suggested that to meet these needs the civilian agencies would have to exploit materials R. & D. sponsored by the defense and space agencies more extensively, plus sponsor their own materials R. & D. He also suggested that each agency maintain materials experts at the appropriate R. & D. management level, and that there be more interagency coordination in these areas.

Harold P. Green, of the George Washington University, pointed out the difficulties in establishing a public policy which on the one hand seeks to preserve the environment, and on the other, attempts to deal with looming materials shortages. He felt that it should be recognized that "the environment exists to be lived in and to be used" and that it "cannot be 'preserved' except in a totally static setting."

He stated that this observation led to an anomaly of nature, if not of public policy: "we cannot use materials if we want to preserve the environment; we cannot preserve the environment if we use materials." He suggested that the real question was: How much environmental change are we willing to tolerate? He then went on to elaborate on the possible policy issues involved in resolving the conflict between materials usage and environmental preservation. Some of the topics he touched upon included confusion between the public sector, (which attempts to maintain environmental quality) and the private sector, (which uses materials and does not expect controls on such usage). He noted that, although it is the assumption that government and law will be neutral, in actual fact they seldom are. For instance, the passage of certain laws to encourage the use of specific materials, may overtly prohibit the use of other materials, and hence cannot be classified as "neutral" actions.

A further difficulty is encountered by the policy maker since the public currently recognizes the right of each of us to make his own judgments when it comes to the decision to use or not use a hazardous or harmful product . . . even when the harm can be incurred by the individual himself. (The case of tobacco was presented as an illustration.) The issue becomes even cloudier when the burden of harm is spread indiscriminately among various classes of persons throughout a wide geographic area. Since it may be difficult to determine, much less predict, the extent of damage that may incur from the use of a particular product, it seemed to Green most reasonable to consider the net harm or net benefit resulting from a balancing of the benefits against the risks.

Green next discussed the responsibilities for protecting the environment. He felt that self-policing on the part of industry would be "virtually impossible" in view of the complexity of interacting factors in most instances. In fact, his view was that "it is the function and obligation of government, and not of industry, to adopt policies and procedures to assure that materials will be used in a manner consistent with maintaining the quality of the environment." However, the dif-

ficulties here included the fact that in this society laws are rarely made except in response to what are perceived to be real and immediate problems; materials are never used unless they are useful; and adverse environmental consequences of the use of materials can rarely be identified at the time the materials first come into use.

He felt that the only acceptable approach to these dilemmas would be the establishment of a technology assessment mechanism to develop and assemble all relevant data concerning the benefits and risks of particular technological elements, and to balance the benefits against the risks to determine whether social controls are necessary. However, Green cautioned that the usefulness of this technique should not be overrated in the case of injection of extremely small amounts of harmful substances into the environment. He thought that no amount of early study could have foreseen the effects of DDT, for instance. Sometimes decisions, therefore, will be based solely on a weighing of the present benefits against the present risks.

Green concluded his extremely thought-provoking paper by stating that it might be a "logical impossibility [for] pollution management [to] keep pace with the growth of pollution in a society committed to continuing rapid technological growth."

Clifford S. Russell, who appeared for Resources for the Future, Inc., took issue in his paper with the widely held belief that "some sacrifice in national economic health will be required to achieve a higher quality environment * * *." In his examination of this topic, he first looked at two major distinctions in the consideration of economic factors. The first was the short versus the long run. In the short run, for instance, previous decisions place an immediate burden on such factors as labor and capital so that any shock to the system which alters demand will probably catalyze unemployment; while in the long run, previous decisions can be altered so that no pocket of lasting unemployment would ensue, since labor, capital, and so forth, would eventually be mobile. The other distinction he mentioned was that between the local and the national points of view. This is a fairly easily understood concept i.e. that a shock to the economic system producing a loss on the local level may produce no loss, or even a gain, on the national level. Russell suggested that "one important policy alternative whenever changes in laws * * * produce regional losses and national gains should be the compensation by the nation as a whole of regions * * * suffering the losses." Thus, he concluded that the "idea that there are 'essential tradeoffs' between environmental quality and economic health results from a confusion between perfectly real, short run, regional problems of adjustment and assumed longer run, national ones." He referred to further confusion generated by the "gurus of environmental quality" who publicized statements about the necessity for dramatic cutbacks in individual consumption, increases in product durability, and so forth. Russell felt that such statements could accomplish little until the Nation's definition of "economic health" changed, so that such changes on the part of individuals would come more naturally. For instance, the future "spaceship earth economy" might require a different appraisal of work—one in which the major reward is the work itself and not the remuneration, and all the attendant outward signs of material wealth such monetary rewards can provide.

Russell felt that the conflict between regional and national goals would mean that the Federal Government would have to apply uniform legislation across the Nation, in terms of possible economic shocks, so that no incentive would exist for industrial plants to move in order to escape strict environmental standards. He pointed to the successful U.S.-Canadian Automotive Trade Products Agreement of 1965 as a model to be used for compensation of groups of workers/communities, and so on, affected by environmentally-inclined legislation which shocks a local economy.

PROBLEMS OF MATERIALS SUPPLY

Earl T. Hayes represented the U.S. Bureau of Mines and surveyed the outlook and trends for minerals supply in the United States. He noted that the United States currently consumed about one-third of the world's mineral output, with only 6 percent of the world's population. He also stated that the Nation was becoming increasingly dependent on foreign supplies. The dominant factors of urgency in this situation included: increasing competition for foreign resources; shortage of trained mineral specialists; the non-renewable nature of many of our mineral deposits; and the transgressions of mining activities against the environment. The only real answer to the looming materials problem, according to Hayes, would be a "massive revitalization and rededication of mineral science and technology." In elaborating on this topic, he noted that one of the distinctive features of the mineral industries is that they are largely based on wasting assets. He went on to list possible technological changes which could foster a minimization of losses in mining non-renewable resources including the development of technology to utilize low-grade ores and improvement of mining techniques.

Hayes stated that "in an age of abundance, technology is no better than it has to be," but further noted that our age of abundance is past. He touched upon the inadequacies of technology in terms of recycling and environmental control and also stated that the manpower available to deal with these problems was critically low.

In closing, he mentioned that a new study was certainly indicated, in order to develop an adequate materials policy for the Nation. However, he warned that the commodity approach used by the Paley Commission, while adequate for the time, could no longer apply. He felt that today "we must focus on the problems of minerals production, broadly defined, and upon the Government policies and activities both foreign and domestic that are necessary to help assure an adequate and dependable flow of minerals to the National interest."

The preservation of the mineral base through the application of appropriate principles of science and technology was the subject of the paper by **Elburt F. Osborn,** of the Pennsylvania State University. He listed the same problems in the minerals supply area as had been specified previously by other speakers. Besides mentioning the need for mining technology which had already been covered, he suggested some other areas which needed coverage: the after effects of abandoned coal mines, such as underground burning, ground subsidence and smoke pollution; the pollution of streams near mines by acid water runoff; and the health problems encountered by mineworkers,

especially black lung disease. He felt that science and technology could make improvements in all of these areas. The technology of petroleum production also received some attention in this presentation. Specifically, Osburn thought that the know-how for controlling blowouts or cleaning up spills from offshore drilling or tanker mishaps was still lacking.

In the area of underground pollution, he listed three major contributing factors which could be helped with new technology: landfill operations for disposal of garbage and trash; burial of nuclear waste materials; and deep well injection of waste waters. In the latter area, he noted that there was some speculation that such injection procedures may have contributed to a series of earthquakes in Denver.

The shortage of adequate manpower in the minerals science fields occupied a good portion of this paper. Besides the declining number of graduates in these areas, Osburn pointed to the fact that universities were actually closing down their mining departments for lack of interest. He felt much of this trend could be attributed to the lack of support on the part of the Federal Government in terms of provision of research funding. He went on to point out that the stance of the United States in the materials science field was suffering in comparison to other nations. This was illustrated by the fact that the number of technical publications by the Soviet Union in areas concerning minerals chemistry was now almost double the number produced by U.S. scientists. His major recommendation in this regard was to "do for mineral resources what has been done in agriculture," namely provide Hatch Act type funding to support education and research in these disciplines. He felt that the "establishment of a mineral resources experiment station at an educational institution in each state is a critical need." The presentation closed with his endorsement of the notion of a cabinet-level Council on Mineral Resources.

W. C. Prinz and **D. F. Davidson,** both with the U.S. Geological Survey, discussed possible approaches to an inventory of U.S. mineral resources in their paper. They emphasized that such a listing could not come about by a "straightforward cataloging process." Although drill samples are taken by private industry in areas of known deposits and then analyzed for content, the acquisition by the Federal Government of such information, which is usually held confidential for proprietary reasons, would be almost impossible. Additionally, they felt that industry typically blocked out only as much of a deposit as needed for a relatively short period of time, rather than taking complete inventories.

Prinz and Davidson stated that what was really needed was an inventory of potential mineral resources. Such inventories could serve other uses than simply helping the Nation to realize its minerals potential. For instance, lands under consideration for the wilderness system could be inventoried and the decision made accordingly; locations of cities and towns could be planned ahead so that valuable deposits of minerals would not be made inaccessible; and taxes, sales, and other property actions could more accurately reflect the actual value of the land. The scientific basis for such potential inventories could be derived from geology. To proceed with the inventory, however, the United States would have to be mapped geologically at a scale adequate for

resource appraisals. They noted that at that time less than one-third of the United States had been so mapped. The major responsibility for such inventories should lie with the Federal Government, although mine owners, counties and states would probably benefit from taking their own inventories.

A working system for the inventory of mineral and fuel resources based on geological considerations was presented by **Cornelius F. Burk, Jr.,** who described recent efforts of this nature at the Canadian Centre for Geoscience Data. He noted that the most important factor in establishing such a system was the acquisition of an adequate information and data base.

MATERIALS AS WASTES—WASTES AS MATERIALS

Richard D. Vaughn, of HEW's Bureau of Solid Waste Management discussed the "solid waste problem" and noted that "there probably never will be a universally applicable solution." The policy in regards to solid waste, in his opinion, should be to "seek to recover and reuse the maximum practicable amount of solid wastes." One of the limiting factors to recycling would be the question of economics, as pointed out by a study by the Midwest Research Institute for the Bureau of Solid Waste Management. That study indicated that "there are definite limits to the quantity of secondary materials which can compete successfully in the market place with virgin materials." He stressed that the ability to recycle materials had not yet approached anywhere near its limit. Vaughn thought that it would be useful to think in more imaginative terms about the concept of recycling—to include, for instance the reuse of a material in a radically altered form. As an example, he cited the heating value of paper, which if incinerated, could provide energy for electrical production or other purposes. He noted that it had been estimated that municipal solid wastes have a heating value of 5,000 Btu per pound, or nearly one-third that of a good grade of coal.

Vaughn suggested that the primary barrier to reusing valuable elements in municipal wastes was the difficulty of separation. He felt that the interim solution was to ask for community cooperation until the technology of mechanical separation could be improved.

For the short-range approach to the existing problems, he suggested that available information be distributed to those with responsibility for the handling of solid wastes; that technical assistance be provided to those planning solid waste management systems; that public information programs be initiated; and that existing laws relating to unsatisfactory waste management practices be enforced.

For the problems of the future, the following long-range program was outlined; the initiation of major research programs on large scale reclamation and recycling; the evaluation in realistic terms of potential markets for reclaimed materials; the development of methods to reduce the volume of waste at its source; the initiation of improved collection and transportation systems; encouragement of the recovery of all usable energy from municipal wastes; and the investigation of new methods to finance waste management systems, including the possibilities of placing a part of the financial burden on the manufacturers of goods which make up the solid waste.

In recounting the progress that has been made to date, Vaughn discussed the five year plan of the Bureau of Solid Waste Management and noted that effective solid waste legislation has been passed in at least six States to date.

The possibility of new approaches to solid waste management was discussed by **Carl Rampacek,** of the U.S. Bureau of Mines. His thesis was that this country has mismanaged its solid wastes, and, in fact, "Americans who produce wastes at a rate reflecting an advanced twentieth century economy still dispose of it by nineteenth century techniques." Among the "wrong" techniques he included the non-recovery of useable minerals and other materials from wastes. He felt that this country was only just "beginning to realize that our three waste repositories contain all we shall ever have of the basic life resources of land, air, and water, and that these repositories are so interconnected that to pollute one may be to pollute all three."

One of the major problems with effective disposal of our wastes was the fact that modern man had developed wastes which would not decay. He felt, however, that technology could be developed to overcome this.

The rest of his paper centered on some of the possibilities for recovery of useable metals or materials from various wastes and a brief outline of some of the new research in these areas at the Bureau of Mines. He closed his presentation with the notion that the Bureau considered solid wastes to be resources out of place—and that research and technology could put them back where they belong.

Philip West, who represented the General Motors Technical Center, lectured on the recycling of materials from automobile hulks. He noted that the main purpose of auto wrecker yards was to provide a central location for the recycling of parts, useable materials and accessories, so that "approximately 88 percent of the cars find their way into the recycling process without intervention and that eventually the bulk of these cars are being used as a raw material." He did feel that the effectiveness of the system could be improved, however, in two major areas: economics and aesthetics.

The possible technical and economic constraints on the effective recycling of major industrial metals were discussed by **R. W. Hale** and **H. W. Lownie, Jr.** Their major conclusion was that the primary constraint was the composition of the materials. This could include such factors as contamination or the presence of undesirable elements. The collection of metallic scrap was considered to be the major economic problem since the process was difficult, expensive and labor intensive. Hale and Lownie expressed the belief that some sort of economic incentive would be needed to get metallic scrap into the mainstream, perhaps along the order of a bounty system.

The subject of recycling man-made ores for industry was covered by **S. L. Blum,** of ITT Research Institute, who felt that the Nation was suffering from the "tragedy of the commons" by not making complete use of its resources, both natural and manmade. The concept of calling a potentially reusable waste by the term "ore" was advocated by Blum, since he felt that such terminology would change our attitudes toward waste. Using such a term would allow people

to think of wastes in terms of their potential use rather than as discarded materials. He thought that identification of specific causes of waste would be the key to use and recycle, i.e., wastes caused by practices of man or by natural occurrences, or other reasons. He suggested that a "logic should be developed to determine effects on the community of wastes and how to compare various potential solutions in some numerical fashion." Such a cataloging would have to include some rating of the possible motivations for recycling: economic incentives to reduce product cost; scarcity of raw material; and effect on community of waste accumulation. He then discussed three possible techniques for rating wastes numerically.

ENERGY, FUELS AND ENVIRONMENT

Alexander Gakner, appearing for the Federal Power Commission, discussed the projected power needs for the next two decades, predicting a four-fold increase in energy demands. He noted that fossil-fueled plants have a conversion efficiency of 40 percent with 50 percent of the waste heat being disposed of through the condenser cooling water. Light-water-reactors have energy conversion efficiencies of about 34 percent, with essentially all of the waste heat discharged to the cooling water stream. If there is not significant change in the quality of fuels used or in environmental control technology, therefore, it can be expected that there will be "a multitude of air and water pollution, solid and radioactive waste disposal, land use, and aesthetics problems." Gakner listed the probable factors contributing to each of the three areas of pollution concern, air, water and land as follows: air pollution will include radioactive gases released from nuclear powerplants (he felt that the technology for control of this was in hand, however); carbon dioxide released in combustion processes could contribute to the "greenhouse effect"; formation of nitrous oxide gases could result from excess air and certain temperature levels in combustion chambers; sulfur oxide emissions could not yet be controlled except by limiting the sulfur content of the fuels; and flyash from powerplant stack gases could currently be controlled with 99 percent efficiency.

The major water pollution problem, with respect to power generation, would be that of thermal pollution. Gakner noted the striking prediction that "by 1990 the waste heat discharged into condenser cooling water will be twice the total heat used to generate all the electric energy in the year 1970." The construction of evaporative cooling systems could present such new hazards as fog or icing during winter months. Artificial cooling ponds might offer another alternative.

The land problems included the possible mismanagement of radioactive wastes and the shear space problem created by disposal of large volumes of flyash. Additionally, mining practices can devastate large areas of land.

In order to better coordinate the Nation's environmental and energy problems, he endorsed the need for a National Energy Resources Council. He felt such a Council should concentrate its attention initially on two needed areas of research: greater efficiency of fuel utilization and utilization of waste heat for space heating and other purposes.

G. Alex Mills, U.S. Bureau of Mines, **Harry Perry,** Library of Congress, and **Harry Johnson,** U.S. Bureau of Mines, presented an extensive paper on the management of fuels to satisfy environmental criteria. They stated that a rising concern for the environment had caused a change in the way fuels are selected. Since each major fuel source has differing environmental effects, these selection procedures have become very complex. Additionally, the authors felt that such policy decisions as are made with respect to oil import programs, public land leasing, tax treatment and prorationing would also affect the management of fuel resources to solve environmental problems.

It was stated that "the production, processing, and utilization of fuels cause most of the environmental problems of the Nation." Many of the waste problems which they discussed in respect to coal mining and uranium mining had been discussed previously. The quality and temperature of water, and how this could be affected by various energy sources, was also covered. Most of these statements were in agreement with those of previous papers. They stated that "nearly 80 percent of all air pollution in the United States is caused by the combustion of fuels"; hence "from an air pollution standpoint, hydropower is the perfect method of generating electricity."

The ideal fuel management system would be guided by a model which relates energy needs to damage, emissions, and fuel availability. Included in the model would be "an assessment of the relative damage among dissimilar pollutants, for example, aesthetics of land versus air pollution, as well as comparisons between a small hazard (nitrogen oxide) versus a large, infrequent hazard (nuclear)." They noted that no such model exists now.

They felt that any policy statements should not overlook the possibilities of technical breakthroughs for new energy conversion devices in such fields as fuel cells and magnetohydrodynamics.

The authors indicated that both the technical community and industry should act to better inform the public of the true costs and benefits to be derived from pollution abatement.

Some of the possible new energy conversion systems were explained by **James A. West,** U.S. Bureau of Mines, who felt that the achievement of such technological breakthroughs would determine our choice of alternative energy systems in the future. He noted that "in combination, there are adequate energy resources in the United States and throughout the world to meet all foreseeable levels of energy demand to the year 2000 and beyond."

The technological developments which promised to have the greatest impact on energy systems by the end of the century were: nuclear reactors, especially breeder reactors which produce more fissile materials then they consume, magnetohydrodynamic generators, which could convert mechanical energy directly to electricity with an efficiency of 50 to 60 percent; and fuel cells which could convert chemical energy to electrical energy. The time-frame for the development of reliable, competitive fuel cells, however, was thought to be highly uncertain.

TECHNICAL ASPECTS OF MATERIALS

In the materials engineering field **Henry R. Clauser,** consultant, discussed the concept of "materials effectiveness" as a means to con-

serve materials through their efficient and effective service application. This would mean that in a given application the material(s) that will most efficiently meet the product and functional requirements or parameters would be used; the selected material(s) would meet the need by consuming the least quantity; and the chosen material(s) would be the most durable and/or provide the longest product life cycle.

Any change in the national materials policy toward a doctrine of materials effectiveness, according to Clauser, would have to recognize that there are often systemic built-in deterrents. By this he meant that plants or industry may be equipped to handle certain materials and be reluctant to alter their procedures readily.

He went on to explain some aspects of materials design engineering and presented some brief examples of how such design procedures could conserve materials. For instance, he discussed the possibilities of designing composite materials for specific uses—these would be "sandwich" materials which would have interior and exterior components to meet specified needs. Another type of materials design would be the use of cast composite structures of two or more materials. In this case the behavior of the material would derive from the structural and geometrical characteristics of the constituents as well as from the combination of materials of different compositions. He stated that "perhaps the most significant aspect of the composites concept is that in some composites the interaction of two or more different macro-constituents provides considerably greater performance than when the constituent materials are used alone."

Clauser suggested that the viewing of materials as "dynamic or functional" would also open up new use possibilities in the future. Examples of such materials would be those that undergo some sort of change when subjected to actual use environment, such as ablative nosecones on rockets. He felt that the most important kinds of materials in this category would be those that could perform the functions of multi-component mechanisms, such as gear trains and those that will transmit and/or transform energy from one form to another, such as transitors.

According to Clauser, the major problem to date in achieving materials effectiveness seemed to be complexity and lack of concentrated coordination of efforts. He thought we should be expending major efforts to learn more about the various structural characteristics and possible interactions of various materials.

As a major policy, he noted that the "future strategy for gaining better, more efficient, less wasteful application of materials lies in promoting the interaction of design and materials." This could be partially achieved with the re-emphasis of materials education to applications and synthesis rather than to concentration on the micro-level as it is now. He further suggested that a "systems approach" to materials and processes would be necessary; one in which the manufacturer of the end product would be closely allied with the production of the materials needed for the product.

Clauser closed his lecture with a call for the establishment of an Materials Register in which "all engineering materials would * * * be listed along with their standard detailed characterization, their processing and property data and their service history.

Jerome Persh of the Department of Defense talked about the process of technology transfer as it could possibly relate to the new National Materials Policy Commission. To do this he summarized the efforts of the DOD in this regard over the years. He stated that his agency had a strict policy concerning this subject to which they adhered: "If the opportunity for spinoff presents itself, it is our responsibility to foster and encourage it, but we cannot let it distract from fulfilling our primary missions." He felt that ultimately the limiting factor in technology transfer is "largely economic," and that the success of transfer is "controlled to a great extent by the technical skill, conceptual ability, and creative drive of the potential recipient." DOD had found over the years that in "three-fourths of the cases in which a new manufacturing process was successfully transferred within the defense community, direct communication between people was necessary."

He listed three misconceptions which are widely-held and act as barriers to the transfer of technology: that most technology is marketable by industry; that DOD technology can always be used directly for commercial purposes; and that technology transfer can be fostered and increased by the initiating agency's efforts alone.

The implication of the points raised by Persh was that the Federal Government must recognize, in establishing a new agency or commission whose purpose is to identify and define the broad subject of materials with respect to national goals and objectives, that technology transfer from the defense or civilian agencies in the materials development area may not occur spontaneously if there are economic disadvantages, even though a dire need may exist. In such cases the government may have to consider the provision of "seed money" to get the transfer process started.

Aspects of the consideration of forest products as renewable resources were covered by **A. S. Gregory** of the Weyerhaeuser Company. He felt that any discussion of a national materials policy should consider three points: the extent to which the needs of mankind can be filled by the utilization of timber crops; the impact on our environment from the growing of timber, its harvest, the manufacturing processes, and the disposal and recycle of such products; and the supply and renewal of timber raw material.

After considerable discussion of the forestry industry in the United States and the potential materials advantages to be derived from the use of renewable resources, Gregory went on to suggest seven policy elements with regard to forest resources:

> That incentives for both the public and private sectors to invest in the business of growing forest crops should be provided;
>
> That incentives for the private investor to place capital in forestry businesses would be needed;
>
> That incentives for businesses to devote their resources to develop improved forestry practices and higher yields of forest products would be worthwhile;
>
> That incentives for institutional and other research organizations to advance the art in these areas would be needed;
>
> That people must be motivated to solve environmental problems by direct action;

That private citizens must be encouraged to help protect the environment by collecting and returning fiber products for recycling;

That the public be better informed about the potential contributions to be made to preservation of the total environment if forests are maintained.

George J. Bair, who represented Corning Glass Works, examined the glass industry as a case study in terms of materials development, substitution and availability problems, environmental considerations, and the recycling of products. He noted that improvements in the strength of glass over the last ten years had been made by the introduction of tempering and ion-exchange techniques. He noted that generally the industry had no problems in obtaining raw materials, but said the industry had not been "happy" with the substitutes they had to go to when an embargo was placed on all purchases from Rhodesia, their original supplier of petalite for lithia.

Although the direct waste problem from the manufacture of glass was termed "very minor", Bair stated that the "disposal of used glass products is of greater concern." Later in his talk he seemed to indicate that the degree of the problem even in this area could be considered to be relatively small since "it has been determined that glass makes up only about 6 percent of municipal refuse." A good portion of this refuse is made up of beer and soft drink bottles, however, and consumption in these areas had shown a marked increase since 1960, so that disposal could eventually become a problem. In regard to the one-trip bottle, and its possible demise, Bair stated that "people in general will not accept the time, effort and nuisance of returning bottles." He did think there were two promising uses for returned bottles (presumably separated and retrieved from municipal refuse): as cullet to remelt in furnaces to improve the efficiency of new glass manufacture; and crushed, as a replacement for crushed stone in asphalt paving mixtures.

ORGANIZATIONS AS SOURCES OF POLICY ADVICE

N. E. Promisel of the National Materials Advisory Board described the possible contributions to be made by the Board (NMAB) in the formulation of national materials policy. First, he summarized the materials needs of certain technologies, the implication of the materials explosion, the social needs which required new materials expertise, the current organizational controls on the materials R. & D. effort of the government, and the balance of responsibilities between the government and industry in critical and selected materials areas. Most of these points had been covered in detail by previous papers presented during the conference.

Promisel then listed the general purposes of the NMAB as they are derived from the functions and philosophy of the National Academy of Sciences. He stated that the three councils, on academia, industry and the government would carry out the major work in defining problems, need, and opportunities in the materials area. In particular, the government council had the following broad objectives:

To provide a forum for discussion of major problems and development of remedies through cooperative government activities;

To examine the total government materials effort;

To evaluate specific areas of research that have been started in support of some urgent national goal; and

To identify national technology gaps and manpower requirements in the light of changing national objectives.

Although the NMAB was limited in that it could not make policy, Promisel felt that an important aspect of the NMAB's work was to "provide the background and recommendations for policy."

Rustum Roy of the Pennsylvania State University gave a brief explanation of the role of professional societies in setting materials policy. His thesis was that "materials policy is not, and cannot be set by the general public and their elected legislators alone." He advocated a system in which the "Nation move[s] toward regularizing and recognizing the necessity and desirability of * * * second sphere representative democracy." This was in reference to his proposal that "every regional and national technological universe be represented in the policymaking process by a defined technology community."

He noted that the materials engineers and scientists suffered from a lack of coordination since they are divided among about two dozen societies which have no contact whatever with each other. He felt that a federation of such societies was needed to eliminate redundancy and to provide coordination, and indicated that discussions about such an organization were underway.

Robert A. Huggins, representing the Advanced Research Projects Agency (ARPA), discussed the role of the interdisciplinary laboratories established under ARPA of the DOD in the materials area. The prime mission of the ARPA was to insure the DOD "against technological surprise" such as had been experienced with the Soviet launch of Sputnik. He noted that ARPA functions as a "special innovative prod" and not as an operating agency.

The interdisciplinary laboratories established under this program were "to provide a special stimulus to the field of materials science because of its importance to the national interest." A major feature of the program was to achieve a substantial increase in the rate of graduate education in the materials field.

The results of the interdisciplinary laboratory program in materials were: achievement of a 75 percent increase in output, as measured by papers published by the associated universities; the development of the recognition of materials as a generic field; a major increase in the sophistication with which the nature of materials is understood; the pioneering of the "central facilities" concept; and an acceleration of the diffusion of new techniques from one technical area into another.

—Summary by Carol Lee McBee.

III. RESOLVING SOME SELECTED ISSUES OF A NATIONAL MATERIALS POLICY

Summary of the Proceedings of an Engineering Foundation Conference (Henniker II.) July 30–August 4, 1972 [1]

The second "Henniker" conference was also held with the support of Senator J. Caleb Boggs and the proceedings were prepared by Dr. Franklin P. Huddle of the Congressional Research Service. The format for this conference differed from the previous one in that the participants were divided into individual task forces and asked to examine specific topics. The proceedings contain the report summaries of the groups which met to discuss each issue. Although all statements were presented to the conference attendees, and some statements experienced minor modifications from the full body, the task force findings were not presented as consensus views for the conference body. The "Preface" noted, however, that "no strong dissent emerged on any of the points offered, which suggests that they warrant some measure of respect."

Three formal presentations were also made by individual spokesmen from three agencies: the Department of Interior, the National Bureau of Standards, and the National Commission on Materials Policy, dealing respectively with national minerals policy, economic opportunities in new technology, and the philosophy of the Materials Commission.

The impetus of the conference, according to Huddle, was to gather together a "substantial and well-qualified group of experts" to present their views and thinking to the National Commission on Materials Policy, which would be in its final year of operation, and to "review some of the major issues with which the Commission was concerned."

Because the conference did not aim for a consensus view on major issues, none emerged. The topics covered were wide-ranging, and did not focus on a single issue, such as the environment or national security.

* * * * * * *

The main proceedings of this second "Henniker" conference in 1972 consisted of the reports of the participants who divided into eight task forces. Each group considered two of the eight topics selected for discussion which included:

Central Government Planning and Coordination;

Opportunities and Responsibilities Facing Private Industry in the Materials Field;

International Competition and Cooperation in Materials;

Research and Education;

[1] Henniker II: Resolving some selected issues of a national materials policy. Washington, U.S. Government Printing Office, 1972. 101 p.

The Effective Application and Management of Knowledge;
The Closed Cycle Flow of Materials;
Demand, Rights, and Responsibilities of the Consumer; and
Economic Opportunities and Constraints in Materials.

To set the tone for the conference, there were a series of presentations on the general topic of materials policy presented by spokesmen for the National Commission on Materials Policy (NCMP), the Committee on the Survey of Materials Science and Engineering (COSMAT), the National Science Foundation, and the U.S. Bureau of Mines.

GENERAL MATERIALS POLICY

James Boyd of the NCMP reviewed the purpose of the National Materials Policy Act of 1970 and the objectives of the Commission established under that Act. He reported that the funds made available for accomplishment of the required tasks, about two million dollars, were found to be insufficient if only in-house resources were relied upon. Thus the Commission and its staff decided that congressional intent had been "that the Commission should constitute itself as a coordinating mechanism to elicit advice and muster help from all elements of the materials community."

Although Boyd described the various mechanisms instituted by the Commission to obtain advice from the materials community, he did not make any substantive statements about the specific areas covered, information obtained, working plans, or projected results of the Commission's work. He did say that three studies had been commissioned from the NAS and NAE, but did not give the topics.

He suggested that the working policy of the Commission should be to "keep loose" since "only by maintaining a flexible attitude, and a willingness to lay aside old dogmas, to recognize the existence of new problems and the need for new solutions, can we hope to fulfill the charge to the Commission."

One of the mechanisms mentioned by Boyd had been the use of regional conferences at eight universities to gain the advice of the academic community. **Charles J. Ryan,** also of the NCMP, gave a brief overview of these NCMP University Forums, especially giving attention to the policy aspects and considerations covered. After discussing the major trends in the materials stance of the United States, Ryan noted that "as U.S. demand for raw materials has increased, the issues of self-sufficiency and foreign dependence have been accentuated but in no way resolved by a coherent national materials policy."

Ryan indicated that, in general, there seemed to be two lines of thought coming out of the various university-held forums. One group of participants maintained that the "structure of current policies is sound, and that remedies for the Nation's materials problems can be found through carrying out the same policies, but to a greater degree." He further stated that the approaches preferred by this group focused on questions of increasing supply and measures that involved technological solutions.

The other group, which was in the majority, was of the opinion that great changes were in sight for the world in general, and the world of

materials in particular. He noted that the main thrust of the recommendations from this faction "revolved around greater efficiency and conservation at every point in the life cycle of materials, with particular attention given to mechanisms that will encourage the process of closing the materials life cycle."

Many recommendations were put forth by both groups, usually balancing each other in the extremes. For instance, one group suggested self-sufficiency for the United States, while the other thought the Nation should rely on foreign supplies to the maximum extent. A middle-ground group, which subscribed to neither extreme, felt that the market system is the best means of allocation, and that the Federal Government should only intervene in cases of national emergency or security.

Although Ryan did paraphrase most of the ideas presented as recommendations in the forums, most had been stated before as part of official policy statements or as suggestions for national policy. Since the forums did not attempt to come to agreement and make recommendations, these will not be listed here. The one idea, mentioned by the speaker, as gaining unanimous approval "as a source of domestic supply" was recycling. The forums also felt that recycling would have beneficial effects on energy conservation and environmental quality.

One interesting idea put forth by these forums was that "the weak link in the chain of long-range human welfare was not resources, but other factors such as food production, pollution, and psychological strain caused by overcrowding."

Ryan reported that "an economic no-growth policy was hardly discussed because it was rejected out of hand." However, he did note that there was some support for a policy of selective growth in the near future. The forums felt that "two seemingly conflicting, but not mutually exclusive, goals are operating in the Nation at the same time—the need to produce goods, and the need to protect the environment."

Broad policy directions which emerged from the forums are briefly summarized below:

> Materials policymaking must use the systems approach in the sense that it should recognize the all-pervasive position of materials in the system and how they affect and are affected by the other elements;
>
> The commodity approach to materials should be expanded to consider the total life cycle of materials (i.e., extraction through recycling);
>
> Two broad courses of action are open to deal with the prospect of materials shortages and/or high costs (social and economic) associated with future demands: (1) expand the supply and (2) reduce materials demand through conservation and efficiency. Both courses are needed;
>
> Environmental resources must be factored into the production costs of materials in order to strike a balance between the two indispensable systems for the Nation's survival and progress: economics and ecology;
>
> Greater Federal R. & D. efforts in the materials area are needed;
>
> Cooperation between the developed and developing countries must be sought for the distribution of world resources; and

Materials policy must recognize that materials are the base of world economic activity and recognize questions of equity between rich and poor nations and citizens.

The forums agreed that the Federal Government had the most serious charge in the area of materials policy to mediate the forces of "production and protection" to the best interests of the public.

A variety of other speakers presented their views on materials policy as representative practitioners in the materials community. Very brief abstracts of their talks are reproduced in the conference proceedings. These abstracts do not give sufficient development of the rationale and facts that went into any suggestions, conclusions, or recommendations to warrant their inclusion here.

NATIONAL MINERALS POLICY

Hollis M. Dole, Assistant Secretary for Mineral Resources of the Department of Interior, covered this topic in his formal presentation. He noted that the Mining and Mineral Policy Act of 1970 did not, for the most part, contain new policy, but simply endorsed and gave the force of law "to a philosophy of mineral extraction and exploitation that has prevailed ever since the founding of the Republic, and which is implicit in most of the basic mineral laws that are already on the books." The one new aspect of the Act was the emphasis given to the policy of environmental protection, which he agreed belonged "in any expression of national minerals policy, because taking care of the environment is of serious concern to the mineral industries, the government, and the public at large."

Dole then went on to summarize the first annual report submitted by the Secretary of the Interior on March 31, 1972 under the provisions of the Act. He particularly emphasized the state of the minerals industries in the broadest sense and commented on trends and events which may have particular significance for the future. His general theme was that "environmental concern * * * poses the difficulties that now face the minerals industries; the insistence on performance standards that are more rigorous than necessary, to be achieved under timetables that are too short for the development of the technology needed for suitable remedies: the denial of access or withdrawal from development of mineralized lands; and the restrictions placed on both consumption and downstream production processes which create problems at the source of mineral production."

He felt that too rigorous and too soon an application of the environmental ethic was pushing the United States into an undesirable position in many regards. As an example, he cited the switch-over from use of domestic coal resources to foreign-supplied oil due to the inability of technology to meet the low-sulfur requirements for domestic coal. As an additional perturbation in the minerals supply area, he noted that the very same regulations could cause a "massive oversupply" in the sulfur industry "unless new uses can be developed for vast quantities of its products."

Dole did state that it would be unfair to blame all of the ills of the mineral industries on environmental considerations. He felt that a lack of manpower, unsafe and unhealthy working conditions in the extractive industries, and the shortage of technically trained people

were also contributing factors. Some of these issues were contributing toward a rapid closing of the technology gap between the United States and other developed nations, and Dole felt that "the shortage of basic technology may limit the expansion potential of the mineral industries even if other bottlenecks are cleared."

Dole felt that the "Minerals Policy Act needs an organization capable of implementing it." He further noted that the transport system available today was barely adequate to meet current needs for moving mineral resources, and would be "pitifully inadequate" for the future. He thought that the Nation would have to "recognize that our own laws and regulations are seriously handicapping the ability of American companies to deal with competing firms abroad which are under no such regulations.

THE ECONOMICS OF NEW MATERIALS TECHNOLOGY

Lawrence M. Kushner, Acting Director of the National Bureau of Standards, summarized the emergence of an overall national science policy which he felt was indicative of the current administration. He stated that the major emphasis in that policy was to maintain the environment for innovation, to draw on the reservoir of technical skills, and to explore the unknown through basic research. He quoted the statements of President Nixon which set forth these policies, and which had the effect of instituting specific programs in the 1973 budget. Specifically, he discussed the experimental programs set up to encourage innovation and to identify barriers to private sector development at the NSF and at the NBS. The program at the NBS is called the experimental technology incentives program, or ETIP, and it was expected that results from that program would help in defining "the ways in which the government can stimulate technology development and use in the private sector."

Kushner explored the possible factors which may have stimulated the administration's interest in a policy geared toward technological development. He identified as a "major" influence the report, prepared by Peter G. Peterson in 1972 while on the White House staff, "The United States in the Changing World Economy." Peterson had traced the decline in the U.S. world trade balance, which had declined even in the areas of trade of high technology products. Peterson's report had focused on the lagging investment in technology development and application in the private sector in both the manufacturing and service areas.

Kushner closed by stating that the implication of such issues for the materials area was that the economic impact of proposed programs must be considered, the programs must be structured for maximum participation by the private sector, and policy makers must take advantage of the special strengths of the U.S. free-market, competitive system.

PHILOSOPHY OF THE NCMP

Jerome L. Klaff, Chairman of the National Commission on Materials Policy, discussed the vantage point from which the views of the Commission were formulated. Although, according to the mandate of the National Materials Policy Act, the national interest is of prime im-

portance, he noted that the Commission enlists the aid of diversified sectors of the American society including consumers, environmentalists, labor, all levels of government, industry, academia, and the scientific and technological communities.

He stated that the NCMP was looking at "the life-cycle of materials as they flow through the Nation's economic and ecological systems * * * at the energy needs to maintain that flow." Their philosophy was that in order to "suggest a coherent and comprehensive policy to the President and the Congress, materials, energy, and the environment cannot be treated in isolation one from the other." In establishing goals for the Commission's work, Klaff stated that the views of those who had testified at House and Senate hearings over the last two years had been examined. He said that four basic targets seemed to be apparent in such testimony, which included:

> Conservation of materials and preservation of the environment;
> Adequate materials and energy for the Nation's economy;
> Materials and energy policies that will stimulate social progress; and
> Adequate materials and energy for national security.

Klaff went on to cite current trends in the materials stance for the United States. He pointed out the increasing dependence on foreign supplies, the increasing competition for those supplies, the defensive practices adopted by domestic industries as a response to government regulations, and the increasing dependence of industry on an ever wider variety of mineral and material resources.

His concluding remarks concerned one of the four basic targets of study for the NCMP, conservation of materials. He cited statistics that indicated the astounding amount of waste generated in the United States annually, the expense required to dispose of that waste, and the very limited extent of the existing recycling efforts on a national scale. Klaff suggested that the philosophy of the Commission would not necessarily be to favor the "recovery of secondary materials over the production of materials from primary sources, because the secondary industry derives its source materials from the primary industry." He did think that "we must appraise the balance between these two materials sources with greater precision than we have in the past."

TASK FORCE REPORTS

The following sections contain brief summaries of the task forces' reports in each of the eight topic areas. It is emphasized again that the reports did not necessarily reflect consensus views of all conference participants, and that two separate groups met to discuss each topic, so that internal inconsistencies, or completely opposite viewpoints, may have emerged.

Central government planning and organization

The main question considered by these task force groups was: where in the Federal Government should there be a top planning and coordination body for national strategy in materials? The first task group presented a short-term and a long-term solution. In response to immediate needs, they suggested the establishment of a White House level council or agency with policymaking authority for the planning and

coordination of national strategy in materials. They felt a more permanent solution was needed in the longer term, however, and endorsed the idea of establishing a Department of Natural Resources as the "ideal solution." The second group went directly to the idea of forming a "new agency" which would function as a policymaking body, coordinate work of all other agencies concerned with materials, and exert influence on international aspects of materials. Discussion from the floor on this topic centered around the practical realities of establishing such a department or agency. If established, participants felt that it should coordinate materials activities rather than be an operating agency.

Opportunities and responsibilities facing private industry in the materials field

The main question for these task force groups was: is there a need to restructure the traditional role of private enterprise so as to strengthen the national response to the challenges and opportunities of a national materials policy?

The first group reported that industry had three basic responsibilities: to develop new technologies; to inform the government and academia of its important materials problems; and to cooperate in the generation of a materials data base. They suggested three government policies with regard to industry: changes in regulations should reflect the need for a time period in which to achieve compliance; relief of antitrust action would be needed for highly segmented industries; and government-sponsored demonstration projects should emphasize use of more durable, efficient materials. They further recommended the establishment of a national institution to provide impartial evaluations of the properties and prospects of new materials.

The second task force felt that there was not a need "to restructure the traditional role of private enterprise." They felt that the private enterprise system assumed the role of promoting self-interests, while the government should intercede through regulations to protect the rights of the public. With enough flexibility on both sides, this process should not be unnecessarily inhibitive. They presented the following ideas, which were a mix of private and government responsibilities, policy issues on both sides, and evaluation of possible "incentives" to industry:

Private industry should assist in the gathering of necessary materials information and should aid in the setting of uniform standards;

Constraints on industry may arise from requirements for mandatory recycling or certain prohibitions on waste disposal;

Additional constraints may arise from health and safety requirements;

Cooperate responsibility must include cost accounting to provide for the correction of environmental degradation caused in the conduct of private business;

Subsidies, taxes, or negative taxes will be most effective in stimulating industry towards emerging national materials goals;

Industry should assume partial responsibility to educate the public to the need to assist in recycling and the elimination of waste;

The jurisdiction in regard to national materials policy should be clearly established and, where needed, regulations should be used to control the utilization of resources; and

In the setting of such regulations, industry should not be required to perform to standards that go beyond the state of the art.

Floor discussion centered around the disadvantages to governmental evaluation of materials as proposed in the establishment of an "institution." The participants felt that the recommendation was "too sweeping" since too broad a scope of function had been proposed for such an institution.

International cooperation and competition in materials

The question considered by these groups was: what U.S. policies are appropriate concerning reliance on overseas supplies of materials in view of rapidly advancing competitors and also the changing policies of developing countries? The first group presented two sets of policy alternatives and their probable consequences. The first of these was based on the assumption that the national goal is to continue and maintain the quality of life in the United States. They suggested three possible ways to sustain and increase the required materials supply to meet that goal: complete self-sufficiency, limited self-sufficiency and conservation of domestic resources by exploitation of foreign resources. All three of these suggested policy routes would incur certain undesirable consequences, including the inevitability of price increases for the materials needed. The second assumption was that there would be a world goal to continue and improve the quality of life on a global scale. In this case the policy of the United States would be to provide materials and technology to other nations to improve their welfare, while at the same time achieving our own national goal. The task force felt this would result in increased international development and interdependence, with mutual benefits and lessened tensions.

The other task force addressing this topic looked at seven separate issues and presented options in each area. They called for a "mixed strategy" in the acquisition of materials from abroad, specifically, "traditional competition for the more plentiful materials; [and] more cooperative attitudes for the more critical and sensitive materials." They felt self-sufficiency (autarky) was clearly an impossibility for the United States, and that in lieu of that the Nation should achieve a "good bargaining position with other nations that we depend upon for materials through diplomatic or other means." On the issue of allocation of resources, the group noted that "worldwide inequalities in * * * distribution * * * have led to a disparity between the needs and the supply of materials from one country to another." They felt that international cooperation, based on "mutual trust and understanding," should be encouraged. On another issue, it was the "consensus * * * that supply and demand, using the profit motive, had been effective in the long run in balancing the needs with an efficient productive capacity and there is no obvious reason why this should not continue to be true in the foreseeable future." Concerning joint ventures between the government and industry, the task force suggested that "regardless of antitrust laws, government-monitored joint research and development on matters of international materials should

be supported and sanctioned." They felt that the question of regulation of multinational companies was outside of their scope. The last issue considered was the national policy with regard to stockpiles. They stated that "where supply of a commodity is concentrated in an unreliable area or where transportation by sea could easily be disrupted, the government should establish some strategic stocks for civilian needs or make provision to do so if an emergency biulds up."

Research and education

The task forces looking at this topic were to explore the following question: what should be the roles of research and education in improving the national position in materials and materials management? The first group felt that cuts in budgets for research and/or development were deceiving in that such short-term advantages as saving money were far outweighed by such long-term disadvantages as lack of new technology and trained manpower. They suggested that the country spend a fixed percentage of its GNP on materials research; and that a larger research effort should strive for a better mix between science and engineering "to make management more receptive to new technological ideas."

The second group concluded that "R. & D." has not been effectively applied in many of the mature industries that are experiencing increasing difficulties in competitive world markets." They suggested that "careful analyses be under taken by appropriate agencies to determine the underlying reasons." On the subject of education they concluded that: cooperation between academic and industrial institutions should be encouraged; that continuing education programs were needed to combat the pervasive problem of technological obsolescence; and that government intervention in the supply of trained personnel would not be called for since "the academic community is responsive to the laws of supply and demand in the marketplace for technical talent." Floor discussion in this area revolved around the perceived need for students to be more involved in real world problems.

The effective application and management of knowledge

These groups considered the following general question: how can information, documents, data, and analytical studies be managed as knowledge resources in support of national materials policy? In response the first task force delineated three problem areas, and suggested three courses of action:

> Inadequate and erroneous information on materials reserves (An information gathering system should be established with legislated mandatory input from industry such that company data would be given proprietary protections);
>
> Recycling of wastes depends largely on the availability of markets (Information regarding the composition, amount and sources of waste should be collected and used for the creation of new markets for recycled wastes); and
>
> There exists a tremendous quantity of data on materials and their properties which cannot be used effectively because of difficulty in retrieval (A national telephone exchange to deal with such information should be established).

The second task force decided that two different subjects were involved in this topic—"the utilization or transfer of technological in-

formation and the development of useful machine readable data banks of information." After noting that history was replete with instances of successful technology transfer during wartime crises, the group suggested that "if there is sufficient motivation to create authority and financial backing, the transfer of technology is really no problem * * *." In the information category, the task force saw a need for more up-to-date standards and specifications for materials, and for more information on extraction, utilization, recovery, and disposal techniques for various materials.

The general consensus of the conferees on this topic was that they could not reach a firm conclusion on the need for legislation to strengthen the management of technical information, although they did agree that the use of technical information was of increasing importance to technological innovation.

The closed-cycle flow of materials

The two task force groups were concerned with the following question: how can improved management of materials be reflected in enhanced value of the materials flow throughout the cycle and reduced volume of wastes that deplete the flow throughout the cycle? The first task force reviewed the major features of the recycling of various materials "as it is carried out currently or may be carried out in the near future." They noted that "in the absence of private profit, the required driving forces are environmental * * *." Among the issues they presented for consideration were: recycling should be taken into account in original design; social controls must be aimed at changing public attitudes from a "throw-away" society; quality deterioration, brought on by recycling processes, creates an obstacle to the closed system for some materials; energy expenditures for production from secondary sources are generally less than that required for primary production of the same material, however, energy requirements of the collection process must not be excessive; and recycling reduces the demand for imports of scarce materials and tends to reduce pollution.

The second group presented the following list of obstacles to the closed system approach: there is discrimination against the use of waste process material; there is difficulty in collection and separation of waste components; product design does not facilitate the recovery of material components; there is no clear assignment of responsibility for recycling; and vested interests create effective barriers. They recommended a "national policy that would provide incentives and disincentives as appropriate for the use of materials in products that would be more durable, recyclable, or readily disposable, commensurate with the costs and benefits of such policies to society." They suggested various forms of legal, economic, technological, and psychological mechanisms that could be used as incentives.

It was noted that this topic elicited considerable floor discussion at the conference. The participants seemed to agree that there was a distinct difference between the recycling of materials and the closed cycle of materials. It was strongly suggested that the creation of a market should be the first policy requirement for either system.

Demands, rights, and responsibilities of the consumer

The question to be examined by these task forces was: what burdens on the consumer are implicit in the concept of improved management of

materials, altered patterns of materials availability, and internationalization of environmental costs? The first task force did not think it would be wise for policy purposes to distinguish among classes of consumers. They also stated that "policies should be sought that maximize the freedom of consumer choice, subject * * * to the constraints imposed by environmental and other external * * * costs." This group felt that there was definitely a "people-factor" to be considered in national policy, as epitomized by the consumer. They stated that it was imperative that there be a "continuing dialog among all segments of society * * * for mutual education and moral obligation" during the formulation and effecting of national policy.

The other task force made the following specific observations on materials policy in relation to the consumer: in order to emphasize to individuals the importance of specific materials or practices, more attention should be given to incorporation of the real cost of materials into the actual price of products; appeal through education will not be sufficient; the limitation of freedom by regulation of use of materials seems inevitable; consideration should be given to letting materials find their natural price; and the Nation operates on the basis of meeting crises as they come, therefore the next subject of attention will be fuels, not minerals.

Economic opportunities and constraints in materials

Among other questions considered by these groups, the most important seemed to be: what are the possibilities and limitations of the free market? The first task force set forth a general goal: to provide economic and regulatory policies that will insure adequate established reserves of materials into the future consistent with environmental quality. They then listed six brief policies which could contribute to that goal: initial use of the most economical domestic resources; continuation of research on extractive and other processes to make abundant resource materials economically substitutable for potentially scarce materials; formulation of national objectives for the recycling of materials; national policy geared to resolve balance of trade problems by adjustment of the export of technological products rather than by the restriction of imports of raw materials; protection against the interruption of foreign supplies by the use of mechanisms such as stockpiling, substitutes and standby low-grade ore processing facilities; and the government should encourage and invest in production-scale facilities that utilize new improved processing technologies.

The second task force seemed to have difficulty in focusing on a single topic for discussion, therefore only brief excerpts will be given from their extensive report to the conference. The problems of supply and demand "are not technological but are due to self-interest groups, economics, and international trade. Therefore, recommendations of a national materials policy to control prices artificially would probably not be accepted by Congress and would therefore have only marginal effect. A group formed predominantly of engineers cannot influence this complex situation." A number of questions had been posed to the task force by the organizers of the conference, and this group chose to simply provide answers, or in many cases, disagreements with the ideas presented, rather than to suggest specific policy for materials. The task force "could not resolve * * * how * * * [to] change the

economy from planned obsolescence to products with considerably extended life." They did think that a historical study of products, costs, life-times, and quality of products produced 20 years ago as compared with the products of today might provide some information in this complex area. In the area of recycling they noted that "it is necessary to conduct R. & D. on low-cost disintegration techniques, achievable both at the design stage and for use in the recycling process. It is not, however, possible to estimate the impact of such research programs on the materials balance."

SUMMARIZING THE CONFERENCE

In a summary statement, Huddle suggested that a number of general axioms with regard to material policy statements had been expressed by the conference participants. This list is reproduced below:

> Flexibility of stance.
>
> Capabilty for vigorous positive action.
>
> Fact finding and analysis on a continuous basis to anticipate the storms ahead and hopefully avoid them.
>
> Pragmatic approach—seeking to learn what works rather than clinging to arbitrary folklore.
>
> Investigating rather than accepting facile excuses for failure.
>
> Strengthening U.S. capabilities where we are weak but not relinquishing leadership where we are strongest.
>
> Applying good management principles to the totality of our materials flow, recognizing the triad of materials, energy, and environment; the triad of research coupled with engineering practice, coupled with strong corporate management; and the triad of government, industry, and academia, where in the last analysis most of our materials problems must be solved. (p. 89)

—Summary by Carol Lee McBee.

IV. ELEMENTS OF A NATIONAL MATERIALS POLICY

Summary of the Report of the National Materials Advisory Board, Division of Engineering, National Research Council August 1972 [1]

This report by the National Materials Advisory Board was prepared on very short notice (in less than two months time) at the request of the National Commission on Materials Policy, which wanted an early identification of issues and problems to whose resolution a national materials policy should be addressed. Thus, the report did not attempt to actually scope out such a policy, with specific recommendations, and so forth, but rather called together a group of experts to "rap" about what such a policy statement should contain. This was done by the formation of seven panels in previously decided issue areas which met in several sessions over a three-day period. A coordinating committee then wrote the report, based on the reports from each panel workshop.

The definition of "materials" for the purposes of this report included only mineral materials, excluding water and forest products.

Seven major issue areas were covered in the report . . . briefly, these included:

> Abundances of mineral commodities; environmental considerations and how they affect materials policy; recycling, substitution, synthesis, and design; metallurgical and mineral processes; governmental incentives and controls; international implications; and manpower and facilities.

The summary of this document expressed some of the beliefs of the writers concerning the allocation of materials resources. It was noted more than once throughout the report, for instance, that there was a "moral" obligation involved in the materials issue. They further noted the downward trend in the U.S. production of raw materials over the last few decades, which placed the United States in the position of importing the majority of needed materials from foreign sources.

The possibility of self-sufficiency in materials for the United States was also rejected by the writers of this report. They indicated that even with massive programs in recycling and enlarged domestic production there would be a 54 percent deficit in our primary raw materials demand by the end of the century.

The writers suggested that new approaches should be considered in formulating a "fresh and flexible" materials policy. Specifically, they felt that "the concept of continuing material growth as an axiom and keystone of such policy needs to be re-examined * * *."

The emphasis on environmental and energy concerns prevalent in the early seventies was also clearly reflected in this document. It was

[1] National Materials Advisory Board. Elements of a national materials policy. Washington, D.C., National Academy of Sciences-National Academy of Engineering, 1972. 66 p.

stated, for instance, that "environmental, social, and energy costs must be counted, along with obvious fiscal costs, as the total price we pay for continuing material affluence."

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The writers of the National Materials Advisory Board report cautioned that their effort did not represent the results of "long deliberation together" but rather represented the "pooled judgments of several groups of people who have been concerned about questions and issues believed central to the formulation of a coherent and workable materials policy * * *." The committee had been called together to identify issues and problems for a national materials policy at the request of the National Commission on Materials Policy. The report noted that it was unlikely that all participants would be in full support of all statements in the document, but that it had generally been agreed that market forces alone could not be relied upon to solve the foreseeable materials problems. The report concentrated on mineral materials; their abundances, environmental effects, manpower needs, recycling, substitution, and controls on extraction.

Although the committee did not consider forest products or water in the writing of their report, they did note that both were essential and critical materials and should not be omitted from any comprehensive materials policy statement.

MINERAL COMMODITY ABUNDANCES

Separate panels discussed each of the seven selected issue areas; so that different premises, beliefs, and assumptions were incorporated into each section of the document. In the mineral abundance area the following premises were stated by the panel:

> To maintain the present standard of living the United States would require large scale use of mineral commodities;
>
> Actual or potential domestic supplies could not support unlimited increase in demand;
>
> The prospect of increasing world competition for raw materials should cause the United States to slow its trend toward reliance on foreign sources, where possible;
>
> Steps taken by the United States to increase its mineral supply must be environmentally, politically, and socially acceptable both within our country, and within the broad community of nations;
>
> The mineral supply problem for the United States was felt to be three-fold . . . discovery and development of domestic resources, adjustment of minerals extraction and processing technology, and assurance of needed supplies from foreign sources.

This panel attempted to classify minerals according to their abundances and availability in the United States. Based on these classifications they made recommendations as to how anticipated shortages of such minerals should be dealt with. For globally distributed, abundant commodities such as salt, cement, crushed stone, and building stone, they believed that shortages were not likely "now or ever in a rational world." A slight variation on this classification included some commodities now imported to some extent by the United States such as

iron, aluminum and titanium. They felt that domestic low-grade ore supplies of these commodities could be developed to meet our needs, but at a higher cost. The committee indicated that for mineral commodities in this classification the United States could be self-sufficient.

The second classification included commodities that were relatively abundant, but unevenly distributed geographically. The two obvious subcategories of interest in this classification would be those commodities abundant in the United States such as molybdenum, potash, phosphate, coal, and possibly copper and lead. The other subcategory included commodities in which the United States was deficient compared to the demand, including manganese, chromium, nickel, fluorspar, niobium, and hydrocarbons other than coal. Only the second grouping, i.e. of those commodities in which the United States is deficient, would require policy action.

The third classification included these commodities whch are intrinsically rare and also geographically restricted. Again, two subcategories were defined; those in which the United States was self-sufficient on a continuing basis, such as boron and cerium; and those in which we were deficient, such as platinum, gold, mercury, tin and tantalum. The writers indicated that the number of examples of minerals in this classification in which the United States had self-sufficiency was "distressingly rare," but felt that future research and exploration could change the situation somewhat.

As a guide to the National Commission on Materials Policy, this panel raised four basic issues concerning mineral abundancies, in the form of questions, which must be addressed by any comprehensive policy statement. They presented skeletal responses to each question, but were not specific as to who should be responsible or how recommended procedures should be accomplished.

These issues, and the committee responses, were as follows:

I. What steps must be taken to insure maximum utilization of domestic mineral resources without unacceptable damage to the environment?

An adequate information base must be provided by completing geological mapping of the United States, studying the origins, distribution, and so forth, of mineral deposits, identifying possible sites of concealed ore bodies, and establishing a central information bank;

Certain lands currently unavailable for mineral exploration, such as parks, wilderness areas, military reservations, towns, cities, highway rights of way, and other Federal, State, or county lands should be opened to such exploration. (The committee noted, however, that this process should be approached cautiously, with top priority given to the control and minimization of potential environmental damage;

Questions of legal tenure in certain large areas of land, such as the continental shelf and deeper sea floors should be resolved so that these lands could be opened to mineral exploration;

Research to develop improved exploration, and detection and sampling techniques for mineral deposits should be developed;

Current mining techniques should be improved, especially with regard to the development of low-grade ores, and the improve-

ment of underground mining practices, (which the committee felt could be less damaging environmentally, but more hazardous).

II. To what extent can domestic mineral deficiencies be alleviated by eliminating nonessential uses of minerals, and so forth?

The committee believed that more conserving practices were advisable at the time, and would become essential in the future;

Implementation of such measures should be supplemented by a study of the tradeoffs necessary in order to arrive at more explicit recommendations.

III. To what extent can industrial technology be useful in alleviating critical mineral deficiencies?

A substantial reduction in deficiencies could be achieved by shifting technology toward the use of more abundant commodities, eliminating nonessential and planned obsolescence uses, R. & D. on extraction from low-grade ores, R. & D. on extraction of useful materials from wastes of mining operations, standardization of products, and more widespread use of presently abundant, but seldom used, commodities;

Improvements could be made in the efficiency of recycling of mineral materials.

The writers expressed their belief that the failure of technology to adjust to available domestic resources could lead to "the erosion of United States mining, smelting, refining, and mineral-based industries, growing economic colonialism, international frictions, a steadily deteriorating balance of trade, and a tarnished global image of the [N]ation."

IV. How can the United States be assured of supplies of minerals, in which it is deficient from foreign sources?

Efforts should be made to develop equitable long-term agreements or mechanisms for exchange of commodities;

Resources in which the United States was abundant, and other countries deficient, could be exchanged for minerals in which we were deficient; and

In the case of intrinsically rare commodities, global exhaustion of the supply would be possible within a century, unless international conservation measures were effected.

The report did not advocate the use of stockpiling as part of a materials policy plan. They noted that "stockpiling is not a conservation measure but an emergency palliative and an implement of price control."

ENVIRONMENTAL CONSIDERATIONS

The panel, which considered the implications of environmental protection policy as it affects national materials policy, was concerned mainly with the provisions of the National Environmental Policy Act (NEPA) of 1970. They wondered whether a realistic and reasonable materials policy could be formulated, given the constraints of NEPA. The possible trend toward the production of demanded materials from even leaner ores was viewed as a potentially destructive environmental force requiring concentrated attention by policy makers.

The panel chose to list selected critical issues impacting on environmental concerns but noted that "time did not suffice for the preparation of thoughtful written responses to all the questions * * * consider[ed] * * * germane."

The issues they considered important included the following:

That environmental cost accounting, to include the cost of preventing or repairing environmental damage to living systems should be undertaken;

That damage from wastes must be recognized and minimized at every step from mine to ultimate user;

That analytical capabilities needed to be established in order to monitor the levels of contaminants from materials-processing and that an agency should be charged, with this task. (The committee noted here that an agency primarily responsible for a developing technology should not be responsible for its regulation.);

That any material resource that is a critical component of biologic systems, such as phosphorus, should be given special attention, to prevent inefficient uses and ultimate depletion of supplies;

That unlimited development of energy resources would unacceptably increase existing problems of heat disposal, and have other environmental consequences, and should therefore receive special management;

That legal responsibility should be established for environmental management;

That areas destroyed by materials extraction should be reclaimed to a point of biological productivity;

That plans should be considered whereby affected regions could be compensated for degradation of their environment because of exploitation considered necessary for the national welfare, or nondevelopment for similar reasons;

That means must be found to extend essential environmental restraints to the entire world, which should be the subject of a special study; and

That it would be essential to establish and preserve a global system of wilderness areas for baseline ecological studies.

The panel on environmental considerations noted that the following areas would require concentrated research efforts if our national materials needs were to be met in an environmentally sound manner: studies of ecosystem dynamics in order to provide better evaluation of environmental implications of proposed materials policies; multidisciplinary research in ecosystem dynamics, which might require modification of existing institutional organizations; and studies to aid in the recovery of ecosystems from past mismanagement such as deforesting, ground disturbance, and so forth.

It was felt that more information about the alternatives in materials and environmental management should be communicated to the general public so that they could participate in policy decisions, and support such policy.

RECYCLING, SUBSTITUTION, SYNTHESIS, AND DESIGN

This section of the report was very brief and contained no explanatory material as to how decisions were reached, or what premises were

used. The major problems in these areas were listed as numerous. They have been classified here into five subject categories:

Incentives to encourage recycling, substitution and synthesis

Incentives to encourage decision-makers and designers to use recycling, substitution, and so forth should be instituted;

The use of market forces or government regulation to encourage substitution should be evaluated; and

Subsidies, taxation and freight regulation should favor secondary materials recovery processes as much as primary materials production processes.

Costs of processing and establishment of markets

Combined or pooled waste-management facilities should be examined where economy of scale would provide more efficiency;

Postitive public attitudes toward recycled materials should be encouraged;

The costs of recycling should be compared with the relative costs in energy and pollution damage, which may be higher for primary production; and

Markets should be developed for materials derived from municipal waste.

Government policies

Policy alternatives to achieve materials conservation such as taxes, rationing, subsidies, natural market forces, and so forth, should be considered;

Governmental institutional arrangements for implementing conserving policies should be evaluated;

Priorities should be assigned in any materials-management system to alleviate shortages, alleviate environmental damage, and take international and security considerations into account;

Government procurement could be used to establish volume markets for recycled materials and for use of non-critical substitute materials;

Ecological advantages and disadvantages of the use or non-use of synthetic materials must be evaluated.

Technology, research, and development

Technology should be improved for the recycling of high priority materials in short supply;

Storage of wastes for later recovery should be assessed;

Technology should be developed to alleviate possible product degradation due to substitution;

The search for substitutes for economic or environmental reasons should be encouraged; and

More research on the use of abundant materials in place of critical materials should be encouraged.

Product design and standardization

Design processes should be altered so that the most abundant, most durable, and most easily recyclable materials are favored;

The use of suitable synthetic materials for critical materials should be encouraged;

Processing methods should be encouraged which waste the least amount of materials; and

Standardization should be employed in product specifications which would promote durability, maintainability, repairability and recyclability.

METALLURGICAL AND MINERAL PROCESSES

This panel felt that the traditional processes employed in minerals extraction were no longer good enough since the available ores were of steadily decreasing grade, and traditional processes employed with these ores would produce environmental damage. They listed about ten general problems and their "alleviation" having to do with extractive metallurgy and mineral processing. Actually, the report does not really list methods or suggested solutions to these problems, but rather seems to ask rhetorical questions about each issue. For instance, they listed the following:

> Many of the process units of today's metal-extraction plants are obsolete. (They say that improvements could lead to improved metal yields, and so forth, but merely ask the question; How can we provide incentives and stimulation for replacement of these facilities?)
>
> Major energy inputs are required in all extractive metallurgy and mineral-processing operations, which can cause serious pollution. (They wonder how we can reduce pollution-potential and reduce energy requirements.)
>
> There are not enough extractive metallurgists and mineral engineers to meet future needs.
>
> The necessity of mining lower grade ores implies that there will be increasing dependence on improved technology. (They note that the issue is: How can we maximize the appropriate utilization of our mineral resources?)
>
> National and international regulations are needed to effectively control pollution. (How can the government establish the required oversight to assure that minerals processing operations are carried out in the best manner to reduce hazards to health and environment?)
>
> The United States lags behind other industrial nations in the development and utilization of new and improved processes for metallurgical extractions. (Here the panel did give some specific suggestions: wastes must be processed more extensively to recover metals, and other useable materials; recycling deserves high priority; improved methods of mineral recovery must be designed; conversion processes to transform abundant fuels—coal, oil, shale, etc.—into cleaner and more convenient fuels must be developed.)

The report goes on to point out that the extractive industry and the colleges of engineering are not prepared to face any of the challenges. They further presented the following examples of selected problems in extractive metallurgy which must receive concentrated attention:

> Coke ovens of conventional design cannot be satisfactorily modified to meet pollution standards.
>
> Continuous reduction and refining processes, although underway in foreign countries, are being ignored in the United States.
>
> Alternatives to the traditional pyro-metallurgical processes are possible (such as electric smelting, solvent extraction, pressure leaching, and so forth) but need intensive study in order to gain widespread acceptance.

Application of tonnage oxygen to smelting processes could help reduce SO_2 pollution.

This panel presented four specific recommendations:

That the establishment of a National Minerals Processing Institute should be explored;

That the programs of the Bureau of Mines should be reviewed with respect to research and development in extractive metallurgy, and so forth;

That policies for utilization of materials should be designed to assure their best and most efficient use; and

That measures should be formulated and adopted leading to replacement of obsolete mineral-extraction facilities.

GOVERNMENTAL INCENTIVES AND CONTROLS

The panel felt that appropriate legislative and other governmental incentives and controls could be utilized to assure a flow of raw materials into the national economy sufficient to maintain its strength during a period of continued growth of population and demand for such materials. They approached consideration of this topic by noting that there were four important issues; that certain trends were apparent, and probably irreversible; that the panel itself would necessarily have certain assumptions and beliefs; and that based on discussions of all the above, a few substantive recommendations could be made.

The various subjects mentioned above are outlined briefly below:

Issues: It is necessary to think of ways to prevent or abate the wasteful use of irreplaceable materials by the private sector. Government actions or inactions could also result in the waste of irreplaceable materials. Materials information should be used more effectively in national policy and strategy. More flexibility of response to challenge should be built into the decision structure.

Trends: The supply of most mineral materials cannot indefinitely keep pace with ever-increasing demand, so that there is little alternative to increased regulation of the allocation and use of mineral resources. Changes in the social values of the Nation are taking place, accompanied by a pervasive distrust of established authority. A new economic protectionism is growing, making the imposition of controls more difficult. The desire to protect jobs and income at home is raising barriers to imports. The American lifestyle is changing as the Nation pays the deferred social costs of past consumption and inequities in distribution (of material wealth).

Assumptions and beliefs: Governmental incentives and controls should be straightforward, equitable and flexible. As much, or more, attention should be paid to controlling materials-consuming growth as to increasing supply. The grant-in-aid, direct or indirect, is a defective control mechanism. The need for efficiency of materials use calls for a study of how individual and collective freedom to waste materials can be most effectively and democratically limited.

Discussions: Since materials positions tend to be volatile, regulation of some kind is needed to dampen fluctuations and hold them within manageable limits. Import restrictions on a specific material, for example, can work in favor of national security and economic

health, but at the same time against national environmental quality. Possible effects and ramifications should be analyzed for any alternatives considered. The panel emphasized the need for restraint of demand as one viable alternative to reducing the depletion of critical materials.

Recommendations: The panel made the following recommendations concerning possible government actions and controls:

That an effective monitoring system for materials supply, reserves, demand, and so forth, is needed;

That materials implications of existing social policies and government programs should be critically evaluated. (They noted that even objectives which are not materials-oriented, such as full employment, and so forth, could lead to resource depletion, materials dispersion and energy degradation);

That national reserves of specific critical materials should be established;

That the government should enter materials markets as needed to achieve essential regulatory objectives;

That the government should consider nationalization of limited stocks of critical materials in special circumstances;

That state and regional economic protectionism should be discouraged;

That there is a need to learn more about social perceptions and attitudes that involve materials;

That incentives are needed to encourage technical developments to use renewable and/or abundant materials instead of non-renewable or scarce ones; and

That any government actions which apply to shared resources should harmonize with those of our neighbors.

INTERNATIONAL IMPLICATIONS

This panel noted that "all signs point to a growing world need for materials. They also stated that available figures indicated that the U.S. position in world production of materials would be less dominant and that there would be growing international competition for acquisition of usable raw materials, especially with the United States. They treated their subject area by raising a number of issues and offering a few recommendations as follows:

It was suggested that a permanent Minerals Advisory Council be formed, composed of representatives from industry, government and academia in order to bring about closer industry-government cooperation concerning materials problems.

The effects of antitrust laws and conflict of interest regulations should be reevaluated in order to protect valid national interests in the international materials field;

In order to provide adequate insurance for overseas investment, they suggested evaluation of the proposed International Investment Insurance Agency;

The Defense Production Act should be extended and sufficient borrowing authority be made available to encourage development abroad of resources believed needed by the domestic economy and national needs;

The International Center for the Settlement of Industrial Disputes should be publicized and used more widely by U.S. companies when dealing with foreign entities;

Policy implications of increasing U.S. imports of oil and gas should be considered, especially the likelihood of obtaining a stable, long-term market;

The possibility of agreement on institutional arrangements affecting marine resources should be explored;

The international responsibility of countries for pollution damage to other countries should be established; and

National policy measures to encourage recycling should be developed.

MANPOWER AND FACILITIES

This panel expressed the belief that a national materials policy must "inevitably include a 'people' policy * * *."

They limited their coverage to mineral science and technology, exploration mining, beneficiation and extractive metallurgy. They also noted that they perceived the need for training to include not only technical but also semi-skilled and non-skilled people. Their single recurring observation was that data on manpower supply was incomplete, inaccurate, misleading, and needed much improvement.

In education, the following problems were listed: the mineral curricula were facing low or declining undergraduate enrollments, indicating a possible future deficit in manpower; better communication was needed to convey demands for particular careers, so that students could make better decisions; materials science teaching and research needed to be better integrated; more qualified people from ethnic minorities and women needed to be attracted to the mineral industry professions; the pros and cons of increasing foreign student enrollment in minerals curricula should be evaluated.

With regard to industry, the following problems were noted: there was a universal complaint that industry under-utilizes trained people; something should be done about the "boom or bust" employment cycle as it relates to the economy; the public image of the extractive minerals industry needed refurbishing; policies in the minerals-industry were ultra-conservative and thus kept them from participating in innovative educational programs as they should; unionization in the industries, as opposed to professionalism of technical people was a growing problem; legislated quotas were not considered judicious incentives for getting qualified people.

Governmental impacts on the manpower situation were addressed as follows: Federal funding of research and student training in the materials field should be increased and diversified; the government's own role in education for the mineral sciences should be limited to in-house training, cooperative programs, and so forth.

The panel closed their discussion of this topic with a few cautionary remarks. If manpower requirements were to be met, substantial supplemental funding would be needed for higher education. They emphasized that funds should come from both the industries, which would benefit, and the government. They agreed unanimously that a national mining school would not be desirable.

—Summary by Carol Lee McBee.

V. INDUSTRIAL MATERIALS: TECHNOLOGICAL PROBLEMS AND ISSUES FOR CONGRESS

SUMMARY OF THE COMMITTEE PRINT PREPARED FOR THE HOUSE OF REPRESENTATIVES, COMMITTEE ON SCIENCE AND ASTRONAUTICS, DECEMBER 1972 [1]

This report was prepared for the Subcommittee on Science, Research, and Development, of the House Committee on Science and Astronautics by Dr. Franklin P. Huddle of the Science Policy Research Division of the Congressional Research Service. The main focus of the study was to present a brief overview of the importance of materials research and development and to relate this R. & D. to present and prospective needs and opportunities in the United States. Huddle therefore attempted to "document the importance of sound materials management to the national welfare."

In defining the scope and limitations of the study, Huddle stated that only those aspects of materials management of interest to Congress were included. He further indicated that the conclusions pointed to the "need for explicit policy, design of programs, exploitation of science and technology, sustained monitoring of the United States position in materials, and a flexible responsiveness to changing problems and conditions in materials supply and use."

* * * * * * *

The working definition for industrial materials used in Dr. Huddle's report was: "materials are stuff, all kinds of stuff that things are made of or with. For convenience here, food is excluded." Thus, "materials" would include materials as they occur in their raw or natural forms and processed materials in their useful forms.

The relationship of materials to national security was emphasized in the beginning of the report. Huddle noted that an important consideration of any materials policy must be the military strength of the United States since "international conflict involves weaponry, and weaponry involves materials." He contrasted the fairly straightforward early responses to strategic needs as characterized by the "National Stockpile of Strategic and Critical Materials Act" with the more modern strategic concept consisting of four basic elements:

> To preserve a healthy economy for the Nation;
>
> To maintain a vigorous, creative, alert, and well-funded research and development establishment;
>
> To encourage and help private industry to develop improved industrial and consumer product technology which could eliminate impairments of the environment; and

[1] U.S. Congress. House. Committee on Science and Technology. Subcommittee on Science, Research, and Development. Industrial materials: technological problems and issues for Congress. Committee Print, 92d Congress, 2d session. Washington, U.S. Government Printing Office, 1973. 24 p.

To continually rejuvenate the Nation's industries and institutions.

Major congressional problems involving materials

Huddle felt that certain trends in the materials area may warrant congressional attention since "materials are indispensable for a healthy economy." These included the following considerations: domestic reserves of minerals in the ground are waning; foreign sources of minerals are subject to political uncertainties, with prices rising, and world competition for foreign sources intensifying; and there are increased demands placed on the materials supply with an expanding United States population. He noted that while stockpiling can be beneficial, if conducted exclusively to maintain a normalizing influence on markets, it may also have the effect of "post-poning necessary national responses to long-term trends in the availability of materials * * *."

He noted that calculations of the extent of dependence of the GNP on materials were useless as indicators of the worthiness of formulating policy, since "as a practical matter, * * * very nearly 100 percent of the gross national product depends ultimately on the availability and use of industrial materials."

Clearly the important interactions of fuels and materials would indicate, according to Huddle, that "congressional interest in the social and political aspects of energy extends functionally and logically to questions of sound management of industrial materials * * *." Such interactions were briefly explained, including the statement that household consumption of energy for heating and cooling can be significantly reduced by proper use of thermal insulating materials.

In concert with others in the materials policy arena, Huddle expressed the notion that "pollution is nothing more nor less than materials out of place." He felt that congressional concern for environmental issues, as shown in an increasing number of statutes, underscored the importance of materials to the preservation of the environment. He mentioned that "the ideal of materials management is the closed cycle of total reuse." Pursuant to the objective of maintenance of environmental quality, he listed a number of areas in which Congress could provide policy, regulation, programs, or other actions. These included such topics as the minimization of solid waste, maximization of the economic utilization of the waste stream, and development of clean industrial processes and clean sources of energy. No new areas were mentioned here that had not been suggested in previous documents, reports, or studies as possible national policy action-areas.

As an example of the type of policy which could affect technological opportunities in materials, Huddle mentioned an administration-sponsored program, begun in 1971, "to stimulate the development, spread, and use of new technologies." He noted that the principal roles in this program to stimulate technological initiatives had been assigned to the National Science Foundation and the National Bureau of Standards. The materials research opportunities which had been suggested to those conducting the programs included such topics as:

Research in the prevention of metallic corrosion;
Research in the prevention of wear, fracture, and rot; and
Research to convert materials into useful products.

Huddle also suggested a number of applied research areas which could benefit from new technological developments including:

Raising the technological level of old, established industries;
Improving the utilization of agricultural products and by-products; and
Improving packaging to provide for disposability, and/or reuse capability.

The opportunities for early legislative action in the 93d Congress on issues relating to materials and the national welfare were categorized into four areas:

Basic economic issues (such as global competition for materials);
Energy crisis (such as materials recycling, use of low sulfur fuels, and coal research);
Environmental quality (such as solid waste disposal and industrial slowdown in response to regulation); and
Economic growth (such as design and process engineering improvement and basic research).

On this same topic, Huddle noted that three studies [2] were expected to be published during 1973 which, "taken together, * * * afford an opportunity for a comprehensive review of the legislative foundations of national policy for research, development, and application of new technology."

An overview of industrial materials

The author presented a very brief overview of the importance of materials to industrial processes. He noted that the myriad of properties of materials made them suitable for almost any application, but suggested that "high priority [should] be given to developing reliable and comprehensive characteristics of materials." Huddle enumerated some of the many possible uses for certain classifications of materials which indicated the versatility of each type. He also suggested that, since the petrochemical industry derives "thousands of different materials like plastics, solvents, drugs, and chemicals" from petroleum, it would be considered as a "material" even if other fuels were not so considered.

The exclusion of food from the scope of materials was considered "arbitrary rather than logical" by the author since products such as leather, sugar, gelatin, and protein glue would be valid examples of industrial materials which derive from animal or vegetable products.

The changing role of materials in the United States

The thesis of the author in this section of the report was that, with the emphasis on occupational roles of Americans changing from agriculture, mining, and manufacturing to service industries in the last half century, there has been a diminished visibility of materials. He felt that this had precipitated a trend "toward reduced contact of American workers, management, and the general public with materials in their recognizable primary forms." Thus, "the direct contribu-

[2] The report of the National Commission on Materials Policy, due to be submitted on or before June 30, 1973; the Second Annual Report of the Secretary of the Interior under the Mining and Mineral Policy Act of 1970; and the report of the Committee on the Survey of Materials Science and Engineering (COSMAT) of the NAS—NRC.

tion of materials to the national economy is obscured," and "from the economist's point of view, materials are of diminishing quantitative importance."

He also noted, as have many other reports and studies, that the United States dependency on materials and minerals from abroad was steadily increasing. Since so many of the really indispensable materials needed by the United States come from abroad, Huddle felt that an examination should be made as to the reliability of the sources and that it should be determined whether adequate domestically produced substitutes could replace these. The latter course of action was not without difficulties, according to the report, since it would not always be easy to find a suitable material available in the abundance needed for substitution, or one that could perform similarly in all the various combinations and uses as the original material.

Huddle noted that some economists take too simplified a view of the ability of America's technological community to develop rapid responses to shortages of critical materials. He explained that "design flexibility takes time, even in more conventional industries" and that it would be "virtually impossible to respond instantly to * * * [a] sudden shortage [such as] might result from the arbitrary cutting off of foreign supplies for some political reason."

According to the author, the question was "not whether the United States *could* pursue a policy of self-sufficiency in materials without total economic collapse. It could. But not without painful readjustments, severe inflation, and an inestimable erosion of individual freedom of choice and standards of living."

The interactions of materials with two areas of immediate public and congressional concern, energy and the environment, were analyzed next in the study.

Bearing in mind the prospect of anticipated United States shortages in both materials and energy, Huddle presented three complex interrelationships which should be kept in mind:

> Energy is required to dig ores, to extract mineral values, to process metals into products, and to recycle the contained materials back into reusable form;
>
> Energy is required to operate the products of industry; and
>
> Large amounts of fuel materials and engineering materials are required to generate, transmit, and retail electric power as well as to harness energy in internal combustion powerplant.

Huddle suggested that considerations of the potential economy of electrical energy through recycling should account for the "electricity content" of the scrap materials. For instance, he noted that even in the case of a low cost material such as glass if "bottles are smashed and remelted, the energy cost is less than that of bottles made from virgin materials."

In discussing the interactions of materials with the environment, Huddle indicated that "all forms of air and water pollution involve materials", but he also felt that "improved management of materials can eliminate or correct the adverse consequences * * *." Exactly what actions on the part of Congress could be taken to achieve this "improved management" were left open to further discussion.

Research and development toward improved management of materials

Huddle noted that two of the most significant contributions made in the past by materials R. & D. efforts had been the discovery and development of new materials or products and the perfection of new and improved processing techniques. These efforts should not be jeopardized, and he felt that the "problem for policymakers is to allocate the resources of the national research effort in such a way as to optimize the range of most useful research products without foreclosing the chances of unexpected breakthroughs in new fields of investigation."

He suggested a number of areas in materials R. & D. where increased efforts could contribute to a general strengthening of the industrial base including:

Locating domestic sources of materials (such as the use of black light for fluorescing minerals and the Earth Resources Technology Satellite);

Mining technology (such as use of plasma torches for drilling and atomic explosives to shatter ore bodies);

Ore refining technologies (such as extraction of aluminum from clay);

Use of abundant materials (such as wider uses for glass); and

Economies in engineering design (such as miniaturization, simplification and facilitation of recycling).

To achieve better R. & D. in the materials area, Huddle stated that improved organization of materials-related activities would be needed. Included would be such ideas as: a better system for collection of technical information about materials; more national guidance on materials usage; and closer relationships between universities and private industry.

Questions and issues

In conclusion, the author pointed to two sets of issues involving research and development in materials which would be likely to come before the 93d Congress for resolution: short-term issues (i.e., those requiring early decisions to meet present needs) and longer-term issues (i.e., those which would require a basic decision on national goals). In the first category, Huddle included such questions as whether there should be a strengthening of the R. & D. base; whether R. & D. efforts should be redirected toward the civil sector and away from the military and aerospace fields; whether mechanisms for technology transfer should be improved; and whether the implications of materials R. & D. for the environment, energy and industrial base should be interpreted as a mandate to action.

The longer-term issues would include the "availability of materials required for United States industry, the balancing of United States export-import trade, environmental factors, a longer-term resolution of the problem of energy balance, and the still unresolved question of the 'limits to growth.'"

Huddle cautioned that some sort of monitoring function would be necessary in any program directed toward the resolution of these issues since "programs that aim to correct today's defects will not necessarily be ideal to correct tomorrow's."

—Summary by Carol Lee McBee.

VI. MATERIAL NEEDS AND THE ENVIRONMENT, TODAY AND TOMORROW

Summary of the Final Report of the National Commission on Materials Policy June 1973 [1]

The National Commission on Materials Policy (NCMP) was established under title II of the Resource Recovery Act "to make recommendations on the supply, use, recovery, and disposal of materials." For the purposes of their report they used the following definition for "materials": "natural resources intended to be utilized by industry for the production of goods, excluding foodstuffs." The NCMP noted that "Commissions are creatures of their times" and that congressional concern during the late 1960's over the interaction between apparently diminishing materials and a degrading environment had been the impetus for the formation of this Commission. The report comprised a great deal of complex and informative background material, statistics, graphical presentations, and tabulated data which were intended to provide supporting evidence for the 198 individual recommendations made in ten different areas. The recommendations were often nonspecific, i.e. suggestions to support, encourage, or initiate some activity or project, most had been presented previously in other materials policy documents, none were prioritized, and a very few were new and/or innovative approaches to formulation of materials policy. Those in the latter category are given special attention in this summary, while the others are presented briefly to give some idea of the general tenor. The first section of the NCMP report, represents the Commission's "summary" of the thrust of their recommendations. It was felt that it would be necessary: to balance the need to produce goods against the need to protect the environment; to balance the supply of materials against the demands for their use; and to manage materials policy more effectively. The subjects of the individual recommendations ranged from creation of new Federal agencies, to revisions of many laws, to imposition of more regulations, to more research and development. The recommendations did not concentrate on any easily distinguishable subject.

* * * * * * *

Summary directives for policy

The NCMP felt that all of the recommendations made in the final report indicated the evolution of three specific "summary directives for policymakers" which could meet the challenge of the mandate to secure a sufficient supply of materials while managing and conserving the physical basis of national life. The Commission stated first that it would be necessary to "strike a balance between the 'need to produce goods' and the 'need to protect the environment' " by extracting full

[1] National Commission on Materials Policy. Materials needs and the environment, today and tomorrow: final report. Washington, U.S. Government Printing Office, 1973.

payment for all resources inherent in a material (including environmental resources) from the users. The NCMP believed that, "Both the need to produce goods and the need to protect the environment are vital; neither should be compromised." The single largest cause for overuse of environmental resources, in the opinion of the Commission, was the prevailing tendency to regard such resources as free. Therefore, it was recommended that environmental cost accounting for all parts of the materials flow system become part of national policy. It was also recommended that in cases where true costs are difficult to assess, "the extraction or harvesting of materials [should] be limited to areas where the ecosystem can be rehabilitated or enhanced."

The second directive which evolved was that policymakers must "pursue an equilibrium between the supply of materials and demand for their use by increasing * * * production and by conserving materials * * *." The NCMP believed that "sufficiency implies a satisfaction of needs above subsistence * * *. It does not imply indulgence in waste, but rather counsels conservation." Too much reliance on currently limited information should not counsel a narrowly-defined policy since "If people persist in assuming that only certain materials will serve familiar patterns of use, they are bound to despair."

Therefore, the Commission recommended that equilibrium could be attained by encouraging an "orderly development of domestic resources" as a high priority; by allowing the continuance of market forces as the prime determinant of the mix of domestic production and imports; by promoting the search for scarce materials by facilitating access to public lands; by facilitating the decision-making process with regard to energy-materials-environment; by according highest priority to research efforts to free the Nation from dependence on fossil fuels for energy needs; by setting consumer product standards which would improve the efficiency of materials usage (via durability, repairability and recyclability); and by establishing a national resource recovery system.

The third summary policy directive discussed was that materials policy must be managed more effectively, i.e. the complex interrelationships of the materials-energy-environment system must be recognized and laws, practices, and regulations should reinforce a uniform policy. The NCMP recommended three changes in policy formulation which could achieve this directive: that an "adequate, accurate, and accessible data base be compiled for * * * policy development"; that "Congress adopt a national land use policy * * * responsive to economic, environmental, social, and security needs"; and that the Nation seek to coordinate and integrate its policy planning in the materials-energy-environment areas by reorganizing the executive branch to include a Department of Natural Resources which would be overseen by a new joint congressional committee.

Illustrative data

The Commission included a significant amount of statistical data on various materials, and how they fit into the Nation's economy. Based mainly on figures prepared by the Department of Interior, the Department of Commerce, and private studies prepared for the Commission, it was possible to make projections of national materials needs

to the year 2000. The feeling was that such figures described ascertainable trends and were "sufficiently authoritative to serve as reliable guides in policymaking."

Not all of the projections, and data are discussed in this summary; however, some of the statements made by the NCMP will serve to illustrate the background against which certain recommendations were made.

In discussing the role of materials in the national economy, the NCMP noted that examination of plots of the GNP, and the values of various materials in constant dollars, led to the conclusion that "services are growing at a faster rate than materials in the national economy."

The report contained projections for U.S. and world materials requirements, especially concentrating on those materials for which the United States was not self-sufficient. The results of projections indicated that U.S. and world requirements for ferrous and nonferrous metals were expected to rise steeply during the balance of the century, while continued industrial development in this country and expanded development in other nations would heavily tax the supplies of energy materials and fuels by the year 2000.

The Commission also examined such other resources as land, water, and air since "all materials are derived from the earth." It was found that major land use in the United States during 1969 had devoted 0.3 percent to mining, 23 percent to forests and ungrazed land, 15 percent to crops, and 40 percent to pasture and rangeland. Of the 2.3 billion acres of land encompassed by the United States, nearly one-third is federally owned. The NCMP also directed their attention to the Outer Continental Shelf since it is believed that the OCS contains large resources of oil and gas, and possibly other valuable minerals. The area adjacent to the United States in the continental seabeds comprises approximately 853 million acres. Only a very small portion of that seabed was currently under Federal offshore leases, for the production of domestic crude oil.

Water was considered to be an "indispensable medium for the production and processing of many materials, and for the growth of agricultural nonfood materials, the production of energy, and the disposal of waste * * *." Therefore, the NCMP felt that attention should be given to the projected U.S. water use and withdrawals to the end of the century. The projections showed an increase by more than 400 percent by the year 2020 for water withdrawals.

An examination of the materials import status of the United States showed that the United States used about 30 percent of the world mineral production, or Gross Domestic Product (GDP) in 1970. Projections indicated that the U.S. GDP was expected to remain at about 27 percent of the world GDP during the balance of the century.

The possibilities for relief of some of the virgin materials demand by the institution of widespread recycling measures were also discussed. The NCMP looked at data which indicated, that during 1967, about 25 percent of the major materials consumed in the United States were recycled. The Commission determined that this percentage could be increased considerably, with special efforts needed in the recycling of old scrap.

Role of materials in American life

To cast this study into perspective, and to better determine the types of recommendations needed for a national materials policy, the Commission examined interactions of materials with the U.S. economy, life style and total environment. The Commission then delineated certain goals for its national materials policy statement based on the assumptions that:

Economic growth will continue with the current tendency toward an increase in the proportion of services over goods maintained;

The trend toward devoting more time to delivery of services and relatively less to production of goods also will persist;

Public concern for the environment in the future will become more influential in the selection of materials and materials processes;

Patterns of consumption will be changed as a result of such factors as price, relative supply, and environmental concern;

Free enterprise will continue to be the basic driving force of the economy;

When free enterprise fails to meet social need, government intervention may mix with the system and provide a strong structure for the organizing of American economic life;

Environmental resources are now seen as national treasures to be husbanded with care and used with discretion; and

In the long term, public policies which stimulate competitive elements within established rules of the marketplace are more effective than direct intervention to achieve national goals.

The Commission set forth six separate goals for its study which are reproduced verbatim here:

I. To increase the stock of wealth of the Nation through materials and environment management in such a way that the environment and the economy are both healthy and enhanced. (pp. 3–8 and 3–9)

II. To provide adequate materials supplies at the lowest possible price compatible with other national goals and priorities of national security, and the conservation of materials and natural resources for the future of America. (p. 3–10)

III. To obtain improvement of the economic, legal, and technological structures of the materials system in such a way that environmental resources used in production are paid for by the beneficiaries. (p. 3–10)

IV. To pursue the opportunity to turn waste into a national resource by returning materials to the stream of the national economy through economic and technological incentives and by changing the linear flow of the materials system into a circular flow. (p. 3–11)

V. To conserve natural resources and materials in every phase of the materials system through economic and legislative incentives designed to diminish toxic and nontoxic wastes, and to encourage, through the same measures, the efficient use and reuse of materials. (p. 3–11)

VI. To formulate materials, energy, and environmental policy in such a way that laws, executive orders, and administrative practices reinforce this policy, not counteract it. (p. 3–12)

The materials system

The Commission felt that the main system in use with regard to materials at that time was open-ended, that is, consisting of only three phases; supply, use, and disposal. In this system, materials are processed to be used and then discarded. However, "recycling makes the system circular and introduces a recovery phase." This new phase would diminish the role of the disposition phase and emphasize materials efficiency. The report went on to state that it was important to remember that the control of materials flow does not lie within either the materials themselves, or the environment, rather it "lies with the human institutions: producers, consumers, technology, and government."

The NCMP then addressed each of the four separate phases of the closed-materials system and made specific recommendations in each area.

Supply: The main characteristic of supply according to the report was that it was an economic service "which assures the essential availability of materials with properties to perform needed functions." Although it was noted that certain materials are favored for specific and familiar functions, it was also clear that "few materials are indispensable to a given use." The NCMP felt it was important to distinguish between the terms "reserves" and "resources". Reserves are defined as those resources whose extent is measured or estimated and which are currently extractable at a profit at current prices and technology. To turn a resource into a reserve it must be located, measured, or its extent estimated, and judged extractable in an economic and technologic sense. The Commission expressed the opinion that "those who express deep concern that the United States or the world is exhausting the natural resources * * * have been thinking only about economic resources or measured reserves, not total available resources * * *." It went on to suggest that in "estimating mineral resources, it may therefore be assumed that some high-grade deposits will be discovered and that resources now economically unfeasible may become workable. Technology and discovery constantly are at work to replenish mineral reserves."

The NCMP felt that whenever a disequilibrium between the constraints imposed on a particular material (e.g. against discovery, or use, or importation) and the Nation's needs built up, then the supply system for that material would be disrupted and the reserves would decline. It was especially noted that this was "the essence of the present U.S. energy predicament." The particular constraints in this case were not elaborated upon at this point in the report. The passage of the Mining and Mineral Policy Act and the Materials Recovery Act in 1970 indicated that Congress had recognized the need to balance constraints and the Nation's needs, according to the Commission. They therefore recommended that the Mining and Mineral Policy Act be adhered to by all agencies in the administration of their pro-

grams, and that any new legislation relating to materials policy be compatible with that Act.

The NCMP stated that exploration for and discovery of new resources were imperatives in the supply phase and that "national policy must stimulate exploration, to turn known and potential resources into available reserves." Possible impediments to exploration and discovery were discussed which included: high costs, legal constraints on public lands, questionable status of mineral rights in the Eastern States and technological limitations. The Commission made specific recommendations in each of these areas which would stimulate the exploration process for future resources. The question of land-use, i.e. for wilderness and other public lands, was treated here, and was also considered in a later chapter. The most important recommendations seemed to be that public lands should not be set aside for single purposes (parks, wilderness) until their mineral and material value had been determined; and that the rights to explore for and extract minerals from public lands should not be denied, as long as provisions were made to prevent irreparable damage to the protected areas. Concerning the other mentioned impediments to exploration, the Commission recommended that research in methods of materials exploration, mining engineering, metallurgy, and material science be supported; that a study be made of the possibilities for making private lands more available for mineral development; that the risks of exploration be "underwritten" by continuation of the percentage depletion provisions of the tax laws; and that the exploration work of the U.S. Geological Survey and the Bureau of Mines should receive more budgetary support.

In the case of foreign exploration, the Commission stated that "once it is recognized that the unique resources of each part of the world qualify for trading in the world market, the developing nations' fear of exploitation will be replaced by a practical bargaining attitude." They therefore recommended that Federal agencies should intensify their efforts to encourage worldwide development of resources by all means available; diplomatic, financial and educational.

Renewable resources, timber and fiber, were distinguishable from other materials, according to the report, in that the reserves grow, and with proper management, the "supply can be perpetuated indefinitely and even, with improved technology, dramatically increased." A number of recommendations were made concerning the timber supplies, all of which were designed to increase and extend the supplies. Such things were included as: use of improved equipment; more research to improve technology; and more efficient and intensive management of the national forests and other public lands suitable for timber growth.

The financial drains experienced by industry during the extraction and processing phases of materials development, were discussed in detail by the Commission. It was felt especially that American industry faced some difficult problems in this regard when placed in competition with foreign suppliers, who had the advantages of lower wage rates for their labor, or the aid of government money to sustain industrial production. The Commission stated that "If private industry is to meet national needs while it carries an unfair handicap

in its race with foreign competitors, it is necessary to devise government policy to offset that handicap." They recommended that the mechanisms available in the Defense Production Act of 1950 be used to reestablish a financial institution to arrange for low-cost investment capital for industry in cases of clear national need. The Commission also recommended that industry-industry and government-industry cooperatives be allowed for production when economies of scale could not be otherwise attained by individual companies.

Use: The Commission explained that the use phase of the materials cycle consists of two aspects: manufacturing and service. Both aspects could be controlled to some degree to minimize adverse effects on the environment, to reduce the cost of environmental protection, and to assure a higher degree of recycling. The report went on to state, however, that the "question of guidance of industrial activities is extremely complex. It involves economic controls, employment controls, employment policy, and direction of capital spending; all subjects clearly beyond our mission." The forces operating on the materials usage patterns in the building and construction industry were discussed and the Commission concluded that this industry was related to population growth and was substantially independent of control.

The NCMP noted that "industrial processing and use of materials, with associated wastes and high energy requirements, create a substantial portion of the stresses in the environment."

The Commission believed that the institution of the closed-cycle of materials use would introduce certain requirements in the use phase itself. For instance, it was recommended that a government agency should issue standards for products which would specify improved service life, repairability and recyclability; find ways to improve the efficiency of materials processing; and study the life expectancy of materials. It was suggested that government practices such as procurement and taxation may affect substantially the use of new or recycled materials, and they suggested that such criteria embodied in contracts and tax codes should be reviewed from the point of view of materials effectiveness.

The Commission submitted approximate estimates of the corrosion and wear losses sustained by the Nation annually, and recommended that the Department of Commerce survey to determine the extent of the losses sustained due to such factors; assess the adequacy of present research: and recommend improved methods for dissemination of pertinent data.

The NCMP cautioned that the government alone could not effect the needed changes in usage patterns and suggested that "Consumers should patronize those manufacturers who are careful of society's needs." It was conceded, however, that this assumed "a much greater sophistication on the part of the public, and a greater sense of commitment and responsibility on the part of manufacturers, than exists today." To partially alleviate this difficulty, the Commission recommended that Congress lead a "national discussion of the structure of the economy and the role played by built-in waste:" and that a high-level government body be assigned responsibility for over-all coordination of materials-related programs of the government.

Recovery: The NCMP considered that "resource recovery deserves to rank among the highest national priorities. We urge the Congress and the Executive Branch to establish recycling as an explicit national goal." The possibilities of retrieving valuable materials from urban solid waste received the major attention of the Commission in this section of the report. It was noted that there were two secondary industries which specialize in handling the waste products of the economy: the sanitation industry for collection and disposal, and the recycling industry for sales of recoverable wastes. Both industries would have to become part of the institutional framework for the return to economic use of solid wastes.

Three specific terms used in the recovery phase were clarified in the report: recycling means to loop a material back into the process by which it was first formed; reuse refers to utilization of a product or a component as is, or slightly refurbished, but usually by a different person; and salvage is the reclamation or conversion, which changes wastes into other and different products.

The Commission was careful to point out that some materials are irretrievably lost during their use phase, e.g. lead in gasoline or rubber treads on tires, so that "recycling by itself cannot overcome material shortages." The report went on to state that it had been estimated that "recycling could provide about 40 percent of material requirements for manufacturing * * * while less than 5 percent of the Nation's yearly total materials requirements can be met from post-user scrap." In discussing the possible savings in the energy area, the NCMP said that "About 2 percent of the total U.S. energy demand could be saved by the recycling of available steel, aluminum, and paper * * * [while] burning municipal wastes, would satisfy about 3 percent of the Nation's energy needs."

Obstacles to the success of resource recovery efforts, according to the Commission, were centered in the marketplace, where virgin materials were given preferential treatment over secondary materials. For instance, favorable tax treatment, freight rates and procurement criteria exist for virgin materials. In addition, labor-intensive separation and collection costs and the fact that plants are equipped for virgin materials processing, act as obstacles to recycling. To alleviate some of the financial difficulties, the Commission recommended that loans at low interest rates be offered to private firms for the recovery of resources from solid wastes; that subsidies be offered as incentives to local governments to levy user charges to citizens commensurate with the actual costs of solid waste handling; that economic incentives in the form of tax credits be given to users of materials if they expand their use of recycled materials; that tax credits be offered to convert or build plants which would be geared to production of marketable products from recycled materials; that steps be taken to correct the existing freight rate differentials between secondary and primary materials; that the government use its procurement processes to provide a market for recycled materials; and that research and development activities in the area of resource recovery processes should be accelerated.

The Commission felt that time would be needed to integrate a recovery-consciousness into the mainstream of American life but that

eventually recycling could "exert a beneficial influence in affairs of growing national concern which stem from * * * exponential growth, resource depletion, energy shortages, environmental degradation, excessive imports, and an adverse balance of trade and payments."

Disposition: The Commission emphasized that, even though recycling should be encouraged and maximized, there would always be some wastes which had to be dealt with. The term "disposition" was preferred, rather than disposal, since this recognized that "the wastes have merely moved to another location." It was noted that the "ultimate disposition of wastes is probably the heavyweight champion of challenges to environmental engineers." The primary sources of waste generated in the United States in 1971 were identified as: industrial (140 million tons), agricultural crop (640 million tons), mineral mining (1,700 million tons), urban (230 million tons) and animal (1,740 million tons). The Commission made some general recommendations to the effect that the amount of wastes should be reduced by recycling efforts; that more practical uses should be found for bulk waste; and industry should dispose of wastes in a manner to facilitate eventual recovery of valuable resources.

Energy and materials

The Commission stated that the "essence of the energy challenge is that domestic reserves of economically recoverable petroleum and natural gas are diminishing * * *." The report went on to suggest that "In planning U.S. energy needs for 1986–2000, the Nation must seek to reduce its dependence on imported fossil fuels, utilize its indigenous fossil fuels more efficiently, and develop other sources of energy, or accept the penalties of energy limitations or environmental disruption."

The NCMP expressed that it was in "general accord with the national energy policy outlined in the President's Energy Message * * *" [2] and went on to list ten steps for the implementation of that policy. These included:

> Using government action to discourage excessive and inefficient uses of energy (especially the removal of price regulations so that market conditions could set the price levels for various forms of energy);
>
> Allowing the surface mining of low-sulfur coal on Federal lands with due regard to land use and restoration;
>
> Allowing exploration and development of oil and gas on Federal lands and the Outer Continental Shelf;
>
> Encouragement of burning of coal for boiler fuel to free surplies of oil and gas for homeowners and small consumers during emergencies;
>
> Expediting the construction of domestic refineries to approach national self-sufficiency in refining and then limiting imports of oil products;
>
> Limiting the imports of crude oil and liquefied gas to an absolute minimum in order to encourage the exploration and development of domestic supplies;

[2] April 18, 1973, President Richard M. Nixon.

Facilitating the licensing procedures for energy plants and facilities by speeding the applications review, making prompt responses to the public interest, and resolving any conflicts of interests rapidly;

Using appropriate tax and other incentives to encourage large capital investments in domestic energy projects;

Accelerating research and development on alternative sources of energy; and

Implementing policy decisions as a stable, comprehensive and long-term solution to national energy requirements.

The NCMP felt that the "goals of clean energy and environmental protection are not mutually exclusive; both can be sought simultaneously." It was noted, however, that "With current technology, some degradation of the environment by the energy system cannot, as yet be avoided."

Certain policy objectives were advocated by the Commission based on the conclusion that "an energy shortage, of severely disruptive and damaging proportions, is a distinct possibility in the immediate future." Some of these included: accelerate development of solutions for the future now; integrate the policies for energy, environment and other materials; expedite the expansion of future power facilities; increase inventories of fuels held by distributors to protect essential activities during periods of emergency; educate the public as to the safety standards for nuclear power so that its development may go ahead; stimulate offshore leasing so that domestic oil and gas reserves may be increased; and consider long-term agreements for imports of oil from selected countries. The specific recommendations put forth in this area included: that the Nation's energy needs be satisfied, as far as possible, from indigenous sources; that tax and other incentives currently used to encourage exploration and development of foreign petroleum resources should be reviewed with an eye to diversion of such capital into domestic development; that restrictive offshore leasing procedures should be modified to encourage their use; that low-cost loans or Treasury guarantees be provided to expedite coal slurry pipelines; and that the United States should join other Western Hemisphere neighbors in a joint energy policy.

The subject of coal received special attention in this section of the report, since the Commission concluded that "the Nation's coal resources are one large national asset that can reduce the energy deficit." A number of recommendations were made to facilitate the production of low-sulfur coal from the Western States. In anticipation of a major movement to the burning of lower-grade coals in the future, the Commission also recommended that attention be given to developing adequate emission control technologies for removal of harmful stack constituents. It was also felt that the development of technology to convert coal to oil or gas should proceed immediately and recommendations were made to that effect. The fact that massive oil shale deposits were to be found on most of the public lands in Colorado, Utah, and Wyoming prompted the NCMP to recommend accelerated development of this single largest source of hydrocarbons on the continent.

In the long-term, the Commission recommended that research and development should be focussed on clean energy sources such as fu-

sion of lightweight elements, geothermal heat, chemical energy sources (the burning of hydrogen), solar radiation, and the extraction of fuel from wastes. It felt that the national program to meet long-term energy needs should be given a high priority such as that accorded the Atoms for Peace program, or the synthetic rubber projects of World War II.

Finally, the Commission addressed the topic of conservation of energy through greater efficiency of use. Certain measures such as the use of mass transit systems, the imposition of a horsepower tax to encourage use of more efficient automobiles, and the return to coal consumption by the electric utilities were suggested as a means to reduce the consumption of oil by two to four million barrels per day in 1985. Even these measures would not alleviate the critical shortage of domestic oil to meet the expected demand, so that other steps would be required. The Commission therefore recommended that building codes should be amended to require energy conservation-pollution control practices; that electric rate structures be revised to promote energy conservation and to curb excessive demands; and that assistance be given to utilities to ease the switch over to coal as the generating fuel.

Environmental factors in materials policy

The Commission noted that despite the fact the "the environment is both the source for materials and the sink for the waste or byproducts of production and use," and that the materials and the environment must interact at all points in the flow, it was clear that "far too few data have been gathered on these interactions." The lack of knowledge in this area was the source of the major conflicts among conservation groups, industry and governmental agencies, in the opinion of the Commission. After reviewing existing environmental legislation the NCMP stated that it was "neither extensive enough in scope nor powerful enough in sanctions to induce the social response desired." It was suggested that any materials policy which expressed a due regard for the environment could manifest that concern by assuring decisions and actions which would balance use of materials and environmental objectives; curtail or eliminate some materials especially degrading to the environment; reexamine the use of such practices as obsolescence, product novelty and over-packaging; and re-orient attitudes of the public, business, and government.

The report examined the flow of materials and described nine major impacts which the flow could have on the environment. These included: the material itself; the stage of the materials cycle (exploration, extraction, transport, processing, use, recycling, and disposal); form of environmental disturbance (discharge, surface disturbance); medium affected (atmosphere, soil, oceans); geographic source of the agent (location); geographic character of the effect (migratory, in situ); character of the effect on humans and animals (direct insult, indirect impairment); degree of magnitude or severity; and temporal factors (rate of change, frequency). Thus, the interactions of materials and the environment could involve some or all of these factors and would necessarily be complex and frequently unpredictable. The report went on to describe some of the known health effects of certain materials, and the effects on vegetation and animals of certain pollutants in water, air and soil.

The Commission believed that it was not possible to blame any one factor such as population increase or technology for the severity of the Nation's environmental damage. It was suggested that "Assessment of technology's role and contribution can be a major step in abating environmental degradation in the course of the materials cycle."

The most important remedy put forth by the Commission for the environmental problem was that a "major goal * * * should be to use institutional arrangements to the end that the full cost of an economic activity is accounted for in its price, including the cost of using common property resources." Possible remedies for the repair or prevention of environmental damage could take the following forms: control or reduction of emissions; protection of ecosystems; dispersal or dilution of emissions; optimal siting; repair of landscape; safe disposition of hazardous substances; and reuse or less use of materials. The types of institutional controls which could attain these remedies could include: threat of private suit; legal prohibitions; use of affirmative standards; subsidies; and direct regulatory action. The NCMP elaborated on the regulatory instruments available: ambient standards, effluent standards, emission taxes, and dispersion of wastes, and described the desirable and undesirable effects of each. The Commission seemed to favor the use of emissions taxes where possible, since "emissions charges have no bias toward any particular method of reducing the emission," but also noted that judgement must be used so that it would not evolve into a "token payment for a license to pollute." A systems approach to the control of materials and environment interactions so that the best methods could be applied to fit particular needs and situations was also advocated.

The Commission specifically made the following major recommendations with respect to materials and environment:

> That cost-benefits analyses should be used to determine the proper decision to be made with respect to use or non-use of certain materials, or processes for materials, and that those responsible for impairments to the environment should bear the costs of repair;
>
> That exploration and production should be restricted to those areas where damage will be minimal and repairs can be effected, except where social benefits are paramount;
>
> Environmental standards should be legislated in areas where still needed;
>
> The issuance of environmental impact statements should be continued for all major Federal programs;
>
> Improved management devices should be encouraged such as systems analysis, comprehensive planning, and coordination of efforts in all materials policy strategies;
>
> Extensive research on the dynamics of the environmental ecosystems should be supported; and
>
> The Environmental Protection Agency should employ cost-benefits analysis when making proposed changes in standards or when contemplating new controls.

Land use

In this section of the report, the Commission explored "the major land use problems which are judged to be crucial to the availability,

extraction, processing, transport, recovery, and disposal of materials * * *." It was noted that not only does the Federal Government own much public land, but it also influences land use on non-Federal lands via its agricultural, forestry, highway, airport, river and harbor, flood control, reclamation, public power, wildlife, and environmental programs. The Commission did not attempt an exhaustive study of land use but concentrated on six topics judged to have the greatest impact on the flow of materials: urban land uses; surface mining; exploration, development and administration of minerals on public lands; availability of public lands; land use requirements for energy supply; and the Continental Shelf. Each topic is covered only briefly here, with the major recommendations given in each category.

The urban land use conflict: The conflict, as the Commission saw it, was between those who wanted materials but didn't want them processed within sight, so that transport costs for many materials were extremely high. Additionally, the short-sightedness of local governments had allowed urban sprawl to pave over choice deposits of materials without their ever having been exploited. It was recommended that comprehensive regional land use planning could alleviate these problems in the future. Included in such a system would be: surveys to locate mineral deposits; use of zoning classifications to reserve such lands until exploited; and regulations to limit noise, traffic, and pollution and to provide for reclamation of such land.

Surface mining: The Commission noted the extreme hostility toward surface mining expressed in recent years, and suggested that "private and public interests must seek not to abandon surface mining but to manage it so as to retain the advantages with the least environmental damage." The NCMP concluded that the responsibility for developing, issuing and enforcing specific regulations should rest with the States, with minimum standards and guidelines being set by the Federal Government. It was recommended that such minimum Federal standards be legislated; that the States then tailor their individual regulations to allow for regional factors; that the Federal Government survey, identify, and evaluate sources of pollution and unsafe conditions associated with surface mining; that research on the impacts of surface mining be undertaken; and that agencies with expertise in such areas as reclamation, land use planning and erosion control share technical information with the States and local governments.

Exploring, developing, and administering minerals on public lands: The NCMP stated that a debate was currently in progress over the management of the Nation's public lands, concerning the provisions of the General Mining Law of 1872, which had been attacked as "obsolete, susceptible to abuse, and inadequate to safeguard the environment." This particular law allows exploration, development and production of minerals on Federal lands to proceed under the location-patent system. A legal title or patent to the surface of the land and the mineral estate may be obtained for a nominal sum under this system by discovering a deposit, filing a claim notice, and proving that the deposit exists. Apparently, this system has been highly abused by those wishing to obtain public land for building sites, timber or other nonmining uses. The Commission recommended substantial revision

of the General Mining Law of 1872 to insure: that the requirements of Federal mining laws and regulations are met; that environmental values are protected; that the land management agencies have authority over the lands; that surface rights are retained by the Federal Government, should the mineral rights be transferred into private ownership; and that royalties be collected on the values yielded from publicly owned minerals.

Another system available for the exploration, development, and production of certain minerals on public lands is called the mineral leasing system. The minerals involved are oil, gas, oil shale, phosphate, sulfur, potassium, sodium, native asphalt, and bituminous rock. The Commission felt that this system is generally working well on the acquired lands and the public domain lands in the five midwestern States. The recommendations in this area were minor: suggesting coordination of mineral leasing laws; giving right of consent for prospecting to the agency managing the land; and suggesting continuance of the system.

The other system available, called the materials disposal system, provides for the sale of common variety mineral materials not covered by the other two systems. The most perplexing problem discovered by the Commission, was that it was difficult to decide what materials would be defined as "common variety." It was recommended that Congress act to clarify this point.

Availability of materials from public lands: This section concentrated on the restrictions placed on public lands classified for recreational uses or for wilderness, wildlife, or scenic beauty preservation. Lands classified for the National Park System cannot be used for the extraction of resources. The National Wildlife Refuge System allows the controlled harvesting of timber, and in some instances, the extraction of minerals are permitted if it does not interfere with the primary uses of the land. The National Forests, at present, partially support the supply of commercial timber resources for the Nation. A new law would, however, allow reclassification of some lands as "wilderness" and hence restrict the extraction of industrial materials. The Commission believed that "the public benefit can be optimized on the National Forests and [Bureau of Land Management] lands by a policy of multiple use" and recommended the acceleration of comprehensive multiple use plans. It was also recommended: that the Congress complete action on an organic act for the BLM; that lands to be designated as "wilderness" be identified promptly; that mineral surveys be taken before lands are withdrawn into such systems; and that economic as well as social values be taken into account when classifying lands.

The Commission also noted that the status of much of the publicly-held land in Alaska was in limbo due to a lack of settlement about which lands were to be designated to the State, as a result of provisions of the Alaska Statehood Act of 1958, and which other lands were to be assigned to the indigenous peoples, as a result of provisions of the Alaska Native Claims Act. Because of this situation most large companies had curtailed mineral exploration there and the Commission recommended that these land transfers take place as quickly as possible.

Land use requirements of the energy supply system: The amount of land needed for the location of electric transmission lines, the sites for power plants and the sites for refineries was discussed by the Commission in this section of the report. The recommendations recognized the need to expedite long-range planning to assure essential services in an environmentally acceptable manner; to simplify licensing procedures for power plant construction; to construct transmission lines in such a way as to have optimal esthetic values; and to encourage joint use of rights-of-way by the utilities where compatible.

The Continental Shelf: It was the conclusion of the Commission that the "mineral resources of the Continental Shelf should be developed to the fullest extent feasible * * *." To that end, it was recommended that the government should collect and disseminate basic geophysical and geological data; that high priority should be given to research in the ecology of the Continental Shelf; that all oil and gas leases contain stringent safety requirements; that new deepwater ports and offshore docking facilities be constructed with the least possible environmental impairment; and that Congress explore the improvement of statutory standards for the strength and safety of tankers.

Water

The Commission explained that water was critical not only as a material itself (steam-electric power), but also in the production (timber, crops); processing (paper, chemicals, petroleum); use (cooling, heating); and transport of other materials. It was recommended that the provisions of the Water Resources Planning Act be broadened. Other recommendations made by the Commission centered around: the more efficient use of water (by reuse of waste waters, desalination, conservation programs, and shifts to high-value users); the preservation and conservation of ground waters (by surveying their magnitude, managing the resources, and monitoring the contents of major aquifers); improvement of the efficiency of water transport for the materials systems; collection and distribution of more basic data on the Nation's water; and improvement of research efforts on disposal of waste heat by power generating and manufacturing plants.

International aspects of materials policy

Many of the topics covered in previous chapters were discussed again in this section of the Commissions' report. For instance, the impact of imports of materials in terms of economics and national security; the role of energy materials and the implications of a national dependence on foreign supplies; the growing competition for materials from developing countries; the risks encountered by investors in developing foreign materials resources; the disposition of the resources of the seabed, and the environmental effects of materials use were elaborated upon. Much of the detailed arguments on these subjects, therefore, will not be covered here.

The NCMP did state that the spate of world conferences held recently: The Club of Rome, the Stockholm Conference on the Human Environment, the Law of the Seas Conference, and the U.N. Conference on Resources and World Population, were an indication of the arousal of worldwide interest in materials and environmental enhance-

ment. The outcome of such interest, it was felt, would be an increasing spirit of interdependence since the "trade-offs between sovereignty and cooperation plus integration will be debated by all nations in the late 20th century."

Sufficiency of supplies: The ultimate question would be the sufficiency of supplies since the United States could not expect to be self-sufficient in materials for which it lacks a resource base. The Commission concluded that "the sufficiency of supply depends ultimately on the growth of demand in the rest of the world and upon the discovery and development of supplies * * *." It was therefore recommended that the United States join the Natural Resources Committee of the U.N. and that the United States encourage the U.N. to allocate funds to surveys and training programs in the field of materials development in developing countries.

Rather than imposing artificial controls on the importation of certain materials, the Commission recommended that the traditional market forces be relied upon as the prime determinant of the mix of imports and domestic production, except: when there is a clear threat to security; or when lower priced imports threaten the viability of domestic production of a basic commodity. The Commission felt that adjustment assistance programs for domestic industries would be needed to ease workers and firms involved in inefficient industries suffering from foreign competition. A number of specific recommendations concerning the particulars of such programs were made.

On the subject of valuable sources of minerals available in the international seabeds, the Commission stated that "international laws provide insufficient ground rules to govern commercial mining in the ocean depths," and recommended that the United States pursue an international agreement to establish a legal-political regime to govern the uses of the ocean floor.

Investments in foreign resources: The Commission considered the high risks faced by private investors who seek to develop resources in the developing countries to be a prime deterrent to the maintenance of needed foreign supplies. Some of the risks included: the threat of expropriation by the host country; demands for higher prices, more domestic processing before exportation, training and employment of nationals for management and skilled technical positions; and more control over exploration, production and marketing of the resources. Thus, the Commission felt that "the prospect for attractive yields on such investments has deteriorated." It suggested that the U.S. Government could pursue "policies to improve the international climate for investment and * * * influence the investment decisions of U.S. companies." To that effect, the following recommendations were made: to negotiate formal international codes to establish the rights and responsibilities of foreign investors; to create an international insurance arrangement for investors in which the countries would assume an appropriate share of the risk; to use an international forum to arbitrate disputes; and to explore the use of executive agreements to establish mutually advantageous conditions for investors and developing nations.

Competition for supplies: The NCMP thought that there was an increasing degree of international competition for the purchase of available supplies of scarce commodities. After reviewing the policies of other industrial nations in this regard, (which included plans on the part of major governments to provide direct subsidies to foreign investors, equity participation plans with resource countries, and the use of favorable loan terms to encourage foreign development) the Commission suggested that American firms may be at a disadvantage, and that two areas should be given attention. The first was to reconsider the impacts of antitrust laws which inhibit the participation of U.S. materials producers in joint ventures overseas. It was felt that foreign competitors were not so inhibited. The second suggestion was to consider the option of economic stockpiling, which could allow the government to stabilize commodity prices should they fluctuate widely on the world market, and which could be distributed strategically in times of shortage to allow time for development of substitutes.

The international competition for sales of domestically produced materials was also thought to be affecting American business detrimentally, partially due to the practice of some foreign governments of subsidizing materials producers, so that their product prices were lower than the comparable American product. The Commission therefore recommended that a detailed study of domestic and export subsidies in industrial countries be initiated and that the present rules embodied in the General Agreement on Tariffs and Trade (GATT), which place limits on such practices, be tightened.

An examination of the projected import bill for materials in 1985 (estimated at $25–30 billion, compared with $10.6 billion in 1972) convinced the NCMP that "materials will neither make nor break the U.S. balance of payments."

National security: With regard to national security, the Commission stated that "It is not within our mandate to specify the degree to which the Nation shall aspire." It felt that the Nation must specify its goals, before the implications for materials policy could be evaluated. For instance, if the Nation were to choose goals with far reaching implications, e.g. political and economic dominance in key world regions, then more capabilities would be required by the Nation to attain the desired level of security. The fact that the United States was partially dependent on net imports of some materials did not necessarily indicate a negative impact on national security, in the opinion of the Commission:

> Although major materials producing countries depend on the consuming countries * * * the dependence is mutual. The key issue is not dependence but net dependence. Interdependence moderates many conflicts of interest among states. Only when the dependencies are not symmetrical, when there is a net dependence of significant magnitude for one nation can anxieties be justified. (p. 9–24)

Certain major difficulties, however, might attend a national reliance on foreign supplies, in the Commission's opinion. These included the possibilities of a general war of nuclear proportions, a prolonged

conventional war, or hostilities which would cause cutoff of supply lines or the formation of unfriendly cartels to deny supplies to the United States. Because of these possibilities, the Commission concluded that "it is unwise to become dependent on specific strategic commodities for which the United States lacks a resource base * * *." The recommendations on this subject included that where problems are foreseen, the United States should:

> Foster the expansion of domestic production; diversify sources of supply; develop special relations with more reliable sources; find substitutes or develop synthetics; increase the dependence of supplying countries upon continuing U.S. good will; and allocate existing supplies through a priority use system. (p. 9–26)

The Commission discussed some new opportunities in foreign markets for resources, namely the Union of Soviet Socialist Republics and the People's Republic of China. It was noted that "Both are well endowed with natural resources which have yet to be developed." In this area it was recommended that a political climate be developed to facilitate access on reasonable terms to the raw materials in both of these countries.

Environmental issues: Environmental issues of international concern prompted the Commission to make a number of recommendations. Some of these called for: the United States to supply information to other countries regarding potential threats to the environment related to materials extraction, processing, transport, use, or disposal; the Nation to participate in arrangements to pay compensation to countries where international decisions on the environment have posed economic burdens; the encouragement of environmental impact statements by international financing agencies; and, the United States to support the right of each nation to decide for itself the quality of its own environment.

Science and technology

The Commission concluded that a deeper commitment to further research and development in the materials area would be needed after examining the economic impacts of worldwide technology, a domestic high standard of living, the maintenance of environmental quality, and the position on free trade. It was felt that "To maintain a competitive position without sacrificing its living standards, the United States must continue to advance its technology to improve its products and productivity. A key to technological progress is research." Further, the NCMP stated that "In some respects, the United States in recent years has lagged behind a few competitors in scientific and technological innovation in the materials field."

The stated goals of the Commission which were felt to impact on this subject area included: the desire to assure sufficient supplies of materials; the need to assess costs and benefits of interactions between the environment and the materials system; and reducing or controlling the dependence on foreign supplies. The Commission made specific recommendations related to science and technology in two of these major

goal-areas, and also suggested some strategies in relation to the scientific and technological enterprise system which could help effect these and other recommendations in the report.

Supply: The Commission noted a need for "clean-burning solid, liquid, and gaseous fuels from fossil fuels, and for developing new forms of energy * * *." The recommendations in this area included: that the government sponsor "a massive research effort" in these areas; that research on fuel cells, high-temperature materials, and economical, clean sources of automotive power be pursued; and that greater priority be given to developing the breeder reactor.

In the general category of materials supply, the Commission made recommendations which would increase reserves, such as: stimulation of rapid development of the geosciences and their application to mineral exploration; develop technologies for utilizing industrial and urban wastes as a source of fuel and raw materials; and support of research to develop feedstocks for polymer production from renewable raw materials. Attention was also given to recommendations to increase materials effectiveness, including: sponsoring R. & D. on improvements in resistance to corrosion and other degradation; research in the areas of nondestructive testing techniques, new composite materials, and characterization methods; and the expansion of materials research programs to include more agencies of the government.

Environmental protection: The Commission stated that "A major technical problem is the inadequacy of present knowledge of the impact of materials-related activities on the environment." This echoed the statements made earlier in the environmental chapter. The major recommendation here had also been stated in the earlier chapter; beyond that, the NCMP recommended developing additional techniques to repair environmental damage and the pursuit of R. & D. on alternate technologies for materials production which would minimize environmental damage.

Research, assessment and application of technology: To encourage and stimulate research on the part of the materials industries, the Commission recommended that the antitrust laws be reviewed in terms of their inhibiting effect on joint industry-wide research; that the government share costs with industry for pilot projects in new materials processes which would provide environmental protection; and that cooperatives between the government and industry be established for the development of new technologies.

The Commission noted that "better tools for assessment of the impact of given technologies on all phases of society are needed * * *" and recommended that the development of the social and economic sciences in an integrated and interdisciplinary way be supported.

Finally, the Commission discussed the strategy necessary for the intensive application of science and technology required for a national materials policy. The devices available to Government which would encourage or discourage new technology were identified.

> Devices available to encourage new technology include operation of government laboratories and grants to industrial and university laboratories; Government purchasing,

> regulations, and tax relief, patents; and other incentives. Government regulations, if insufficiently considered, can be counterproductive in unexpected directions. Those which may have an adverse impact on technological development are zero tolerances, certain elements in building codes, irrational material specifications and standards, aspects of antitrust regulations, and elements in patent procedures and laws. (p. 10–11)

It was also emphasized that in "the pursuit of new technology by way of R. & D., the role of basic research must not be lost." The recommendations of the Commission on research priorities included: that agencies with responsibilities in the materials field should build up their research capabilities; that appropriate basic research relevant to materials should be pursued; that national laboratories and industry should cooperate, as appropriate; and that agencies generating new technology should alert the public and stimulate the transfer of technology to industry.

Instruments of materials policy: Continuing the examination of strategies to enhance the role of science and technology in materials policy, the Commission suggested that the government should support efforts to supply qualified professionals to critical materials industries. It was recommended, therefore, that the NSF analyze the number of graduates to be needed by the materials industries and that support for education and training emphasize the aspects concerned with materials extraction and processing.

Various instruments of policy were also examined by the Commission, such as standards, specifications, and patent policy. The Commission noted that "standards and specifications, designed to ease the flow of goods, often act instead as barriers to innovation and change." It was felt that standards could also encourage waste and inefficiency unless revised periodically, especially in the building industry. It was recommended that uniform national codes should be developed cooperatively for the building industry, and that these codes should be based on performance rather than descriptive standards.

In the area of patent policy, the Commission noted that certain problems existed, especially with regard to protection from imported articles manufactured under a domestically patented process. No recommendations were made in this area, however, the Commission did think that the subject of patent rights, for research projects jointly sponsored by the government and the private sector, should be examined.

Organizing for Government action

The Commission felt that the arguments that had been presented throughout the report indicated a strong need for a comprehensive coordinated approach to the development of public policies for materials, energy, and the environment. They recommended reorganization on the Executive level to establish a Cabinet-level agency for materials, energy, and the environment, "along the lines of the proposed Department of Natural Resources." It was further recommended that congressional reorganization would be required in order to form a joint committee having legislative jurisdiction approximately parallel to the program responsibilities of the proposed

agency above. This would have the effect of eliminating the conflicts in policy which are characteristic of many of the existing laws.

Recognizing that such a massive reorganization would take time, and feeling that the problems were serious enough to warrant immediate action, the Commission also recommended an interim organization in the form of a temporary Natural Resources Coordinating Committee, to be established "at the highest policymaking level, to begin the task of integrating materials, energy, and environment policy."

The Commission also addressed the "so-called 'fourth branch' of the government," i.e. the Federal regulatory agencies. It was stated that "the present regulatory structure * * * perpetuates processes and relationships which may frustrate a national policy favoring rational and far-seeing use of natural resources." The NCMP recommended, therefore, that "the regulatory Commissions, to the extent necessary for coherent policy development, be brought into direct association with our proposed organizational structure."

Inventories of materials

The Commission had been instructed under title II of the Resource Recovery Act of 1970 to determine the "feasibility and desirability of establishing computer inventories of national and international material requirements, supplies, and alternatives."

After examining the need in the United States for such an inventory system, examining existing mineral information systems, and determining the functions that such a system could perform, the Commission concluded that it was feasible and desirable to establish such an inventory in the United States. It was recommended: that the process should begin immediately, organized under the Department of Interior, until a comprehensive Department of Natural Resources could be established; that a qualified staff should be established to test the accuracy and reliability of data obtained from various sources; that economic, technological, environmental, and social elements influencing resources should be included in the inventory; that existing computer facilities should be used, where practicable; and that existing inventory systems should be incorporated if possible.

—Summary by Carol Lee McBee.

VII. NATIONAL MATERIALS POLICY

Summary of the Proceedings of a Joint Meeting of the National Academy of Sciences—National Academy of Engineering October 25–26, 1973 [1]

In the summer of 1973 three separate studies were published ("Materials Needs and the Environment: Today and Tomorrow," by the National Commission on Materials Policy; "Materials and Man's Needs," by the National Academy of Sciences; and "Mining and Minerals Policy, 1973," by the Department of the Interior) which made recommendations on the development of a national materials policy. The National Academy of Sciences and the National Academy of Engineering held a joint meeting in October of that year to discuss the reports, the materials situation, in general, and to put into perspective "the available information on the size of the Nation's reserves, the possibilities for increase or substitution through research and technology, and extension of their use and reuse through conservation, recycling, and innovative applications of wastes and pollutants."

The report of the meeting contained the papers and related discussions presented at the two day meeting. The separate papers were grouped into six subject areas: Goals and Policies; Resources and Reserves; Nonrenewable Reserves and New Technology; Options for Unconventional Resources; Options for Materials Technology Policies; and Men, Institutions and Needs. It was noted in the "Foreword" to the report that the meeting took place during the renewed Arab-Israeli conflict, which resulted in the five month oil embargo by the Organization of Petroleum Exporting Countries (OPEC). As a result, a great deal of the conference discussion concerned energy materials.

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This two day conference was jointly sponsored by the National Academy of Sciences—National Academy of Engineering for the purpose of discussing three materials policy documents which had been published during 1973. To facilitate the presentation of ideas, the lectures were divided into six separate categories.

GOALS AND POLICIES

In his paper on the role of materials in the Federal Government, **Emilio Q. Daddario,** Director of the Office of Technology Assessment, pointed out that certain traditional beliefs were currently being reassessed. These were that our national resources are inexhaustible and that growth for the sake of growth was good. However, he con-

[1] National materials policy. Washington, National Academy of Sciences, 1975. 215 p.

tinued, the many reports on the problems involved in establishing a materials policy had produced more advice than could be handled. He felt that now it was time to set priorities among the recommendations and act on them. He stated "we must either develop and support a rational policy in the efficient use of our resources to escape the exhaustion or misuse of our physical assets or allow that deficiency to restrain our society's growth and add to its tensions in its own random way." Daddario emphasized the fact that the problems in materials, energy, and the environment depend on science and technology for their solution and therefore on the development by the Federal Government of a broad national science policy. He stated that the planning and implementation of a science and technology policy as applied to materials and the environment must be a coordinated effort and he supported an idea for the creation of a Department of Natural Resources.

James Boyd, Executive Director of the National Commission on Materials Policy (NCMP) provided a brief summary of the basic concepts presented by the NCMP report released in June 1973. Boyd first emphasized that current shortages had been caused by "defects within the human political, social, and economic structure rather than through actual resource deficiencies." He then listed the five basic principles of policy recommended by the NCMP report. (See summary No. VI in this report.)

Boyd also stressed that policy statements are worthless without courses of action and that this would require the setting of priorities. He felt that the NCMP had done this by dividing the recommended actions into three major areas designed to:

> Strike a balance between the need to produce goods and the need to protect the environment;
>
> Strive for an equilibrium between the supply of materials and the demand for their use by increasing primary materials production and conserving through recycling and greater efficiency-of-use;
>
> Manage materials policy more effectively by recognizing the complex interrelationships of the materials system so that the laws and administrative practices reinforce policy and not counteract it.

Finally, Boyd concluded that once actions are recommended, steps must be taken by the State and Federal Governments to adopt them.

Morris Cohen, Chairman of the National Academy of Sciences' Committee on the Survey of Materials Science and Engineering (COSMAT), outlined some of the implications for national materials policy taken from the Committee's report "Materials and Man's Needs". He also made the point that the COSMAT and the NCMP reports had approached the subject of materials in different ways. Specifically, the Commission emphasized materials as commodities of trade and manufacture whereas the COSMAT had stressed the technological aspects of materials. Cohen presented a list of statements which summarized the findings of the COSMAT report which included: materials, energy, and the environment are parts of the same vast system, and any policy dealing with one will affect all; interdisciplinary research has become essential to progress in complex fields

like materials but universities generally harbor a resistance to this; and advances in materials and related fields depend on a continuous supply of new knowledge from a balance of applied and basic research. Cohen concluded his paper by listing the recommendations of the COSMAT report (see pp. 19, 20).

RESOURCES AND RESERVES

Vincent McKelvey, Director of the U.S. Geological Survey, outlined the minerals position of the United States. He defined "position" as a comparison of current U.S. production with that of other countries and with previous domestic production. He saw that position as basically strong but went on to point out some problem-causing trends. These included increased mineral imports caused by a dwindling supply of readily accessible domestic minerals which made imports cheaper; continuing increases in demands for minerals in the United States; and increasing minerals demands in other countries. McKelvey stated that he had considered a U.S. Geological Survey assessment of potential resources in the United States, which had included consideration of presently undiscovered sources. He concluded that for only a few metals would there be enough resources to meet the demand after about 100 years. He believed that the Nation could not depend on natural market forces to make the necessary adjustments in supply and demand, but must implement the means to continuously monitor trends and take the necessary steps to influence supply or demand. Specifically, he emphasized the need to study the processes by which new resources are created and supplies are extended.

Edward R. Cliff, consultant, discussed the U.S. and world timber situation. He stated that although present growth exceeds removal, the greatest growth is in the kinds of timber and in areas that do not meet the greatest need, and called for more extensive application of science and technology to the production and utilization of timber in the United States. Looking to the future, Cliff listed three factors of importance in policy planning: (1) with a tightening supply situation in the United States, this country will find it increasingly difficult to supply wood products to other nations; (2) per capita consumption of wood products is increasing at a faster rate in the rest of world than in this country which could make it increasingly difficult for the Nation to compete for wood products from other countries; and (3) production in timber surplus countries may drop following liquidation of old growth natural forests, which would affect U.S. imports. Cliff concluded his paper by cautioning against becoming too dependent on other parts of the world for our basic wood requirements.

Preston Cloud, of the University of California, covered the following three major points in his papers:

> Present trends in man's occupancy and utilization of the earth cannot be sustained;
>
> To attempt to do so will, in time, prove to be a ruinous course for mankind; and
>
> The momentum of the system is such that corrective measures must be initiated long before the desired responses can materialize.

He concluded with the point made in an earlier paper—that the many recommendations of the NCMP, COSMAT, and similar reports were meaningless unless actions were taken to implement them. This he believed must be done through "thoughtful, incentive legislation and effective, coordinated research, surveillance, and action."

In his paper **Bruce C. Netschert,** of National Economic Research Associates, Inc., drew some parallels between the situation for minerals policy and that for energy policy. In so doing, he presented a view in contradiction with earlier papers. As a specific example, Netschert stated that he thought market forces would take care of mineral scarcities by forcing prices up and driving demand down. This was the concept that McKelvey had warned against as an unacceptable basis for future planning. Netschert cautioned against panic and hasty actions in the face of scarcities and concluded that what is needed is a better informed consumer to make more economically rational choices. He believed that in this way scarcity would take care of itself.

NONRENEWABLE RESERVES AND NEW TECHNOLOGY

David Swan, representing Kennecott Copper Corp., discussed opportunities for increasing U.S. mineral supplies through technology and concluded the best possibilities lie in:

> Improving the total yield from known mineral deposits through more efficient mining and concentrating techniques; and
>
> Conserving the available reserves through continued development of improved materials systems.

Swan also pointed out that there are several external factors affecting improved production that have nothing to do with technology. He stated that such factors would emerge from policies in such areas as finance, taxation, and the environment. Swan saw, as the most important of these external constraints, the availability and cost of capital.

In his paper on strategies for oil and gas, **Harry Perry,** of Resources for the Future, Inc., first pointed out the difficulties in determining what the resource base for these energy materials is currently. He stated that estimates on years-to-exhaustion for oil and natural gas liquids range from 23 to 42 years, and for natural gas, from 21 to 43 years. Whether the high or the low estimate was correct, however, he emphasized that the need for improved energy resources was clear. Perry went on to discuss the various technologies available to satisfy our oil and gas needs in the future. He stated that exploration investments for oil are risky because of inadequate technologies and emphasized that more research is needed if onshore resources are to be recovered at reasonable costs. Perry also believed special research efforts would be needed to develop offshore drilling techniques. Secondary and tertiary recovery methods were discussed along with the need for development of stimulative methods for increased efficiency in natural gas production. For the long run, Perry believed energy needs must be satisfied by the use of other sources such as solar, geothermal, and fusion energy. He saw the best opportunities in the development of synthetics for oil and gas and discussed the state of oil shale, coal gasification and liquefaction technologies.

Walter L. Finlay, of the Copper Range Co., gave a paper, which argued for increased research and exploration of a particular mineral—copper at a copper mine on the Keweenaw Peninsula in Michigan. Though the easily accessible deposits had been worked out during the time between the Civil War and World War I, Finlay pointed out that estimates indicate that at least 12 billion pounds of leachable copper remain in the Keweenaw mines. Finlay explained that because deposits are found in isolated pockets, drilling would be too expensive since the drill would very often miss the pockets. He stressed that the best opportunities for profitable recoveries lie in molecular mining. He stated that pilot programs in this method have been undertaken by the U.S. Bureau of Mines and the NSF, through the Michigan Technological University, and that application of the method should start as soon as possible. He felt the best place to start would be in the Keweenaw mines.

Possibilities to increase mineral supplies were also discussed by Columbia University representative, **Menelaos D. Hassialis.** He believed that increases would be possible through improvements in three areas: exploration, exploitation, and recovery rates of mining, milling and extractive metallurgy. In exploration, Hassialis stated that improvements were needed in data acquisition, processing, and interpretation. In exploitation, Hassialis discussed ongoing research to develop in situ recovery methods. He also pointed out that investments in projects to exploit mineral supplies were affected by the price of the end product on the open market. He suggested one way to insure profits on investments would be to use some sort of tax benefit, subject to the constraint that the product be sold only within the country and at a price competitive with import prices. Improvements in the recovery rates of mining, milling, and smelting could come from two fronts, according to Hassialis. First, it must be understood why recovery rates are low and then new and improved solutions must be applied to the problems. Second, when applying these general solutions they must be modified to best suit the particular mineral concerned.

Paul C. Henshaw, of the Homestake Mining Co., concentrated on the many areas currently under study to improve mineral exploration techniques. His list included: improved studies of relationships between plate tectonics and the origin of ores; improved understanding of the physics and chemistry of supergene and lateritic ore deposits for the better exploration of uranium, aluminum, and nickel; and the wider application of geochemistry to prospecting and the study of ore deposits. Henshaw pointed out that expenditures for exploration have declined in the United States in the past year. He blamed this on rapidly rising exploration costs which had been caused by several things including price control, regressive taxes on production, pollution regulations and other governmental controls. Henshaw concluded that although some controls are necessary they must be established with foresight for future needs.

The last paper under the "Nonrenewable Reserves" subject heading, by **William E. Shoupp,** of Westinghouse Elec. Corp., listed six alternatives to ease U.S. dependence on oil and gas. The first, suggested substituting electricity for many of the services and functions we now

do by other energy means. Second, he proposed making more use of the rejected heat from certain types of electric generation plants, by locating certain plants in the cities where this use of heat would be feasible. Third, Shoupp called for the development of coal gasification and liquefaction techniques. Fourth, reserves could be expanded through further exploration with immediate concentration on exploratory drilling off the East Coast, the outer Channel Islands, and the Gulf of Alaska. Fifth, Shoupp called for greater government support for the development of deepwater extraction techniques. And sixth, he suggested the substitution of methanol for most current uses of gasoline. Shoupp concluded that only through the development of these presently limited areas could the United States hope to meet its future energy needs.

OPTIONS FOR UNCONVENTIONAL RESOURCES

Donald H. Stewart, of the Batelle Corp., addressed some of the problems and opportunities in the development of the various classes of geothermal energy. He pointed out that the dry steam systems are the easiest to develop but are rare. Therefore, he believed future development efforts must be concentrated on the other classes of geothermal energy—hot water, hot brine, geopressure, hot rock, and magma. Besides the technological obstacles to be overcome Stewart pointed out that most of the geothermal land is public land. He noted that the Department of Interior, which controls much of this land, has yet to lease any of it for development since they are giving most of their attention to the review of environmental impact statements. Stewart also stated that the best opportunities for effective development lie in cooperative programs with industry. He believed that, only if the research and development work was done in the field, by those who would be working with the systems, could theory be put into practice successfully.

An optimistic picture of the potential usefulness of solar energy was outlined by **Lloyd O. Herwig,** representing the National Science Foundation. The objectives of the U.S. solar energy research program as headed by the National Science Foundation were listed as:

> To provide the research and technology base required for the economic terrestrial application of solar energy and to foster the implementation of practical systems to the state required for commercial utilization;
>
> To develop at the earliest feasible time the potential of solar energy applications as large-scale supplemental energy sources;
>
> To provide a firm technical, environmental, social, and economic basis for evaluating the role of solar energy utilization in U.S. energy planning.

Herwig stated that the area in which the most advanced solar energy research had been done was for its utilization in the heating and cooling of buildings and he believed it could be applied in an economically feasible way by the early 1980s. Herwig concluded that the whole federal solar energy program was currently working rapidly to make solar energy an important alternative energy source for the future.

David J. Rose, from the Massachusetts Institute of Technology, presented a survey, in rather technical language, of projected fuel

resource and construction materials needs for the development of fusion power. Based on the two major schools of thought regarding the type of fusion reactor that will eventually be used, Rose concluded that fuel availability was no problem but that some construction materials were in short, and even critical, supply. Elements that would present supply difficulties included lead, niobium, beryllium, vanadium, and molybdenum. Rose pointed out that, although the laser fusion system was presently less developed than the magnetically-confined fusion plasma system, consideration should be given to the fact that the latter type of fusion reactor makes smaller demands on such critical materials.

The next paper discussed the recovery of conventional resources, i.e., petroleum and natural gas, from unconventional areas. By this the author meant the extraction of such materials from the ocean at greater depths than those of the continental shelves. The author, **Kenneth Emery,** of Woods Hole Oceanographic Institution, pointed out that the major obstacles to increased production were the needs for new engineering techniques and difficulties in the settlement of sovereignty and royalty rights. Emery went on to discuss the opportunities for development in the four kinds of deep-water areas with the greatest potential: the continental rises, deep marginal basins, deep-water salt domes, and pagoda structures of the deep-ocean floor. He concluded that test drilling had been delayed by the factors mentioned above and by the politically effective protests made by environmentalists. As a result, the development of deep ocean fossil fuels had not progressed from the speculative to the status of even hypothetical reserves.

Edwin W. Tooker, of the U.S. Geological Survey, considered the potentials of the Earth's crust as a source of mineral raw materials. He discussed the present status of geochemical knowledge of the crust which basically consists of silica and silicate ores. He then looked at the possibilities of extracting the conventional and unconventional resources present in these basic earth crust components. Tooker emphasized that these extraction possibilities were dependent not only on developing new technologies, but on adequate supplies of energy for their extraction and use, and on our ability to solve the environmental problems involved. He added that efficient use through conservation and the development of stockpiling technologies are essential parts of a complete policy in this area. Tooker concluded that the first step must be to formulate long-term resource identification policies and to anticipate technological breakthroughs.

OPTIONS FOR MATERIALS TECHNOLOGY POLICIES

The first topic addressed under this heading was an economic view of an energy and materials policy. In determining technological needs **J. Herbert Hollomon,** of the Massachusetts Institute of Technology, stated that determinations must be based on two questions: what are the market requirements, and which institutions in our country and in our time should we depend on to ensure that the needs are fulfilled? He saw as the most important change affecting market requirements in recent years, the fact that some of the economies of the industrialized world have grown more rapidly than that of the United States, thus

putting increased demands on the basic resources of the world. Relative to the second question, Hollomon considered the role of the government in the largely private system that produces energy and materials in the United States. He saw that role as one of overseer of the system, to assure its adequate functioning, to correct deficiencies in the market, and to provide for the public good (such as protecting against international actions affecting this country).

Julius A. Mirabel, representing the General Electric Co., presented a brief look at solid waste management, drawing conclusions based on the NCMP report and on a waste management program recently implemented in Connecticut, on what steps are needed. Mirabel explained that the NCMP report presented an extensive discussion of disposal versus resource recovery in solid waste management. He stated that 70 percent of urban solid waste is combustible and he noted that estimates of energy recovery revenues in the Connecticut resource recovery system were substantial. He therefore concluded that the energy/materials recovery system would be the best strategy for waste management. Mirabel also pointed out that as a result of the strong publicly supported drive for environmental improvements, coupled with indications of good economic returns from resource recovery, States and municipalities would implement such programs themselves without a great deal of Federal support. As an added point Mirabel warned against future protein shortages and suggested the development of a program to convert agricultural wastes to livestock feed.

The Director of the National Bureau of Standards, **Richard W. Roberts,** stressed the importance of developing technologies to assure the most efficient utilization of materials resources and looked at some of the work of the NBS in that area. He described work at the NBS in energy conservation based on: new developments in building design, the use for space heating of excess heat developed in on-site electric power generators, and attempts to better inform the public through distribution of leaflets on energy conservation and a program of labeling appliances as to their energy consumption. The NBS program for non-energy materials conservation, Roberts explained, is based on minimizing waste from the corrosion of metals, increasing the reliability and performance characteristics of materials, and looking at the possibilities of using substitute materials for those in short supply. Roberts summarized his paper by stating that any national materials policy will be useless unless work is continued on the development of new technologies based on materials research and development.

The paper by **S. L. Blum,** of the Mitre Corp., looked at recycling with an emphasis on three components that he believed must be considered in the development of a successful policy. They are technology, economics, and institutional factors. In the case of recycling solid waste for energy production Blum described it as being technically and economically possible. However, he noted that strong institutional arrangements would be required to insure that the technological and economical factors can be carried out. Blum concluded that before a policy can be worked out, a national goal must be defined for recycling.

Congressman Mike McCormack restated the point made in a number of other papers—the importance of a national materials policy

to the Nation's entire economic prosperity. Although some initiatives have been taken, he concluded that the present Federal effort for the development of such a policy is inadequate. He suggested that the greatest need was for the establishment of a focal point to coordinate the materials R. & D. efforts of government, industry, and university. He described an executive proposal for the establishment of a Department of Natural Resources as having the potential to produce more confusion, since such a department would encompass everything from public land management to nuclear weapons. McCormack suggested instead the development of a department encompassing science, energy and space with divisions for R. & D., fuels, energy planning and management, environmental protection, human health and safety, and conservation. He further explained that in the R. & D. division a major subdivision should be established for materials.

MEN, INSTITUTIONS, AND NEEDS

The first paper under this heading, by **Daniel C. Drucker,** of the University of Illinois, discussed the importance of education to supply adequate manpower to solve national problems. Drucker stated that a serious misconception of many who talk about a national materials policy was that the national supply of educated manpower was sufficient to solve the problems involved if only enough time and effort were devoted. Drucker emphasized that the Nation must return to the concept of educating everyone to the highest level of his or her ability if any of our national problems are to be solved. Drucker addressed the needs in materials science and engineering specifically, and concluded that the most important need was for universities to bring their efforts in materials engineering teaching and research up to a level equal with the efforts in materials science. Only in this way, Drucker believed, would a successful materials policy be possible that addressed the problems ranging from extraction to recycling.

The part played by institutions in the development of a materials policy was addressed by **L. Keith Caldwell,** of Indiana University, based on the recommendations of the National Commission on Materials Policy. Caldwell emphasized that to meet national needs there must be changes in institutions that would not be just rearrangements of structure but which would reflect changes in the fundamental concepts underlying materials policy. Examples of such concept changes included the move away from an unquestioning commitment to growth, awareness of increasing U.S. vulnerability to shortages of materials, and expressions of detente with the Communist world. Caldwell pointed out that, although there would be opposition from many fronts to meaningful institutional changes, the Congress and President must take steps to implement such changes guided by recommendations such as those in the NCMP report.

A paper co-authored by **Alan G. Chynoweth,** of Bell Telephone Laboratories, Inc., and **Roland W. Schmitt,** of the General Electric Center, surveyed the needs and priorities for research in the various steps of the entire materials cycle. The need, simply stated, was that man would continue to need "things and services" which would depend on a continuous supply of materials. Opportunities for satisfying this need echoed many of the topics discussed earlier, including

substitution, recovery and recycling, and improved performance. Chynoweth/Schmitt also looked at the opportunities in other areas of technology, such as electronics, space, transportation and health, which are dependent on materials research. To take advantage of these opportunities it was pointed out that various needs in applied and basic materials research must first be met and specific examples were discussed. Finally, priorities were examined and a new approach to the setting of priorities was urged. The authors presented tables of specific priorities in basic and applied materials research and explained that these were based on replies to questionnaires sent to nearly 1,000 people in the materials community. They cautioned against looking at such priorities as rigid but suggested their use as aids in setting perspectives in the establishment of materials policies.

The final section under this heading grouped together statements by five different authors under the single title "Parameters of Policies." First, **Franklin P. Huddle,** of the Congressional Research Service, Lib. Cong., pointed out that the Nation is presently facing the need for radical change on many fronts. He stated that the biggest problem facing those in decision-making positions was to have the strength to make bold changes and to determine the direction of such changes. **Harold W. Paxton,** representing Carnegie-Mellon University, emphasized the need for the materials community to make those outside of the community aware of the role materials will play in the solution of all societies problems. Next, **William A. Vogely,** of the U.S. Department of the Interior, presented some points of disagreement with the NCMP report. These included a criticism of the lack of emphasis on the need for a research effort to understand the institutions whereby society makes its materials decisions and an objection to putting a high priority on the development of unconventional energy sources. **Eric A. Walker,** of the Aluminum Co. of America, talked about the weaknesses in the technology assessment process such as how to determine what is a good assessment, and emphasizing that some future variables are impossible to predict. He also talked briefly about the development of new processes. The final paper, presented by **Nathaniel Wollman,** University of New Mexico, addressed the environmental aspects of materials policy. He concluded that the environment was undervalued relative to materials and stated that steps should be taken to substitute labor for materials in various areas. An example he presented was to substitute labor for pesticides in agriculture.

The NAS–NAE meeting report concluded with a dialogue between the program participants having a technical orientation and those having a policy orientation. The discussion chairman was **H. Guyford Stever,** Director of the National Science Foundation. Commentaries of several program participants on what had been discussed during the two-day meeting followed. Appendices to the report contain the recommendations of the NCMP report, the COSMAT report, and the Mining and Mineral report of the Department of the Interior, 1973.

—Summary by Elaine B. Carlson.

VIII. MAN, MATERIALS, AND ENVIRONMENT

Summary of the Report of the Study Committee on Environmental Aspects of a National Materials Policy 1973 [1]

This report was a compilation of the individual study reports of several National Academy of Sciences-National Academy of Engineering teams which dealt with various environmental aspects of a national materials policy. The report tried to provide some answers and recommendations relating to the question posed by the National Environmental Policy Act of 1969 (P.L. 91–190), that is, how can the Nation "create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans?" It attempted to take a "new look" at the economic and technological processes involved in materials by incorporating within these processes safeguards designed to arrest, abate, and reverse the trend of physical and social degradation of the environment. The report stressed that there might be a fundamental human right to a quality environment and that Federal policy should be based on this premise. The report proposed, (1) a major reordering of national priorities toward environmental quality at the expense of traditional production processes and economic growth and (2) national planning to implement those priorities.

* * * * * * *

The major thrust of this study by several National Academy of Sciences-National Academy of Engineering teams was to assess how a U.S. materials policy may be affected by national environmental policies and international relations.

The principal conclusions of the report were that:

1. It is in the national interest that policies and practices aimed at satisfying the Nation's need for materials essential to social well-being should reflect and accommodate at all stages, from extraction to waste disposal, considerations of environmental cost to human health, quality of habitat, and stability of ecosystems.
2. This principle should be included in all pertinent policies and legislation stipulating the right of each citizen to a healthful environment in accordance with Principle I of the Declaration of the United Nations Conference on the Human Environment.
3. The resources of all countries should be regarded as part of an interdependent habitat rather than merely as possible sources of supply; and our national policy should therefore

[1] National Academy of Science, National Academy of Engineering. Environmental Studies Board. Man, materials, and environment. Cambridge, Mass., the MIT Press, 1973. 236 p.

conform to the principles of conduct adopted by the community of nations in a common effort to protect the human habitat and its resources.

4. While we can today identify and deal with environmental problems relevant to a materials policy, and while we are prepared to propose appropriate remedies, the incomplete state of our knowledge requires urgent, systematic expansion of research and of the institutional arrangements needed to widen the data base. (pp. XI–XII)

Like many other recent and related reports on materials policy (for example, "Materials and Man's Needs", and "Mineral Resources and the Environment", the COSMAT and COMRATE studies produced by those committees of the National Academy of Sciences, respectively), this report emphasized the materials-energy-environment triad and in fact extended the concept of "interrelatedness" to include land, water, and population. Likewise, the report endorsed the concept that materials move in a complex "materials cycle" throughout the earth as a whole, across man-made international boundaries, from exploration and extraction, through use, to ultimate disposal or reuse.

The COMRATE report, mentioned above, stressed that technology would not be able to close the growing gaps between rising demands for, and limited supplies of, materials resources. In a similar vein, the report being summarized here emphasized that "the environmental ills presaged for the United States cannot be completely avoided by available technology."

These reports both indicated that materials policy must involve more than the application of technology; really what was inferred was a rearrangement of national priorities from a wasteful "consumption-throw away" mode to a "conservation-environmental quality" mode.

An interesting and potentially important concept discussed in the report was that American citizens (and people in general) had a "right to an environment that is not only healthful but possesses a beauty that reflects regard for and insistent action to cherish and preserve its natural qualities." Specifically, the report recommended the "examination of the need for and the development of both an amendment to the National Environmental Policy Act of 1969 and to the Constitution of the United States declaring that the right of an individual citizen to a safe, healthful, productive, and aesthetically and culturally pleasing environment shall not be abridged."

The study committee assumed that a materials policy designed to protect the environment would be accompanied by a "compatible population policy" although an examination of such a population policy was beyond the committee's mission.

The study committee reached a number of general conclusions, including:

Economic growth should be guided along a path consistent with policies designed to improve the environment.

A national materials policy must incorporate the principle that environmental costs, measured as the aggregate of social losses suffered as a consequence of impairment of the environment, are taken into account in the computation of benefits and costs of any

action to extract, transport, process, use, or dispose of any material. Such costs should be borne by those responsible for them.

Land use planning and appropriate incentives are essential instruments for a rational materials-energy-environmental policy.

International policy should be consistent with domestic materials-energy-environmental policy.

Expansion of research and development and data collection are essential for the adequate formulation of materials-energy-environmental policy.

(See pages 4 through 6 of the report for the detailed conclusions.)

The report warned that the Nation may have underestimated the need for prompt action in regard to materials utilization and environmental protection. Many environmental hazards were only dimly visible at this time. Knowledge about the interaction of man, materials, and the environment was limited. Even assuming prompt action, there were long leadtimes in effecting many environmental improvements. Moreover, some environmental insults could be irreversible. This increased the possibility that some environmental disruptions could be catastrophic, that is, unstoppable by human intervention after they reach a certain point. Even many of the foreseeable problems could not be solved now by available technology. In short, the report stressed that the magnitude of the long-term materials-environment problem was such that a major reordering of national priorities toward, and a major national commitment of financial resources to, environmental quality was called for. Such a commitment would require a national effort with Federal direction. The report identified nine interrelated factors that contribute to the complexity of materials-energy-environment policy. The identified factors were: the specific material(s) involved; the stage of the materials cycle involved; the form of the environmental disturbance; the particular environment abused; the geographic character of the (1) source and (2) effect of the disturbance; the character of the damage to human welfare; the magnitude of the damage; and the time factors.

In evaluating the effects on health of emissions of materials to the environment in excess of natural levels the report stressed two essential principles:

> In the absence of evidence to the contrary for a general population of persons of various ages and initial states of health, no threshold of exposure to toxic substances should be stipulated below which exposures are considered to be harmless. Instead, the effects of exposure should be assumed to be directly related to the levels of concentration of the toxic materials and the levels of resistance of those persons exposed.
>
> The concept of total human body burden of toxic materials should be the significant indicator of exposure, rather than burden acquired in one or another part of the environment or for one or another toxic material. (p. 12)

The study noted that there was relatively little knowledge of the health effects of many materials, especially if contacts were at a low but sustained level and the materials affect the body slowly.

The committee's concern with the environmental effects of materials use may be summed up with the following quote:

> Evidence of scarred landscapes, air pollution, water pollution, litter, depleted stocks of fish and wildlife, environmentally provoked morbidity and mortality, and fewer natural refuges to which man may repair are all directly attributable to the ways in which we extract and use minerals and forest products. The study committee believes that present concern for the environment is neither misplaced nor exaggerated. **(p. 14).**

The remedies suggested by the study committee for preventing or repairing environmental damage included reduction and dispersal of emissions; improved protection of, and repair of damaged landscape and ecosystem; optimum siting of unavoidable damage; and concentration and safe disposal of materials. Specific techniques selected by the committee for detailed study include emissions taxes, effluent standards, dispersion of wastes, land and water conservation and reclamation, land use planning, improved design standards for pollution abatement equipment, and the disposal of unwanted solid wastes.

Because fuel materials were an especially important and complex materials problem at the time and would be in the future, the committee believed that "an energy policy should be developed for the United States that will be based upon due consideration of environmental impacts, with recognition that costs of fuels and electric energy will be correspondingly increased." Moreover, because exhaustion of the world supply of fuel materials could occur within a short period of time, "a government policy directed toward elimination of large-scale, highly inefficient use of petroleum and natural gas, for which substitute energy sources are currently available, is of prime importance." The committee also emphasized the critical need for remedies designed to maintain the productivity of renewable resources.

Recommendations

The committee's major recommendations were the following:

Costs/Benefits—those responsible should pay environmental costs

1. A national materials policy should be based upon the principle that calculations of benefits and costs associated with the extraction, transport, processing, use, and disposal of materials, should take full account of the value of common property resources and of any change in the value of common properties resulting from the impact of materials on the environment; and should support the principle that those responsible for impairment of the environment should bear the costs of damage or repair. These principles should become a commonplace element of property rights, legislation, and administrative practice at all levels of government.

Human exposure—standards need revising

2. In establishing health and safety standards, the traditional concept of a threshold must be modified to reflect that it does not represent a safe level of exposure for unusually sensitive members of the population. Health and safety laws and practices should also recognize

that total body burden rather than exposure in selected environments should serve as the basis for establishment of safe standards. * * * Sufficient baseline surveys and studies of specific populations over time should be undertaken and monitoring networks should be developed and utilized to reveal threats to the health of man and other parts of the ecosystem not only from the gross changes of which we are already aware but also from the slow and subtle changes that are suspected.

Using land, air, and water—planning is needed

3. Federal legislation should be introduced that calls for and provides administrative coordination of land use planning, atmospheric zoning, and the zoning of water resources at federal, state, and local levels, and that coordinates with the planning of [other systems]. * * * Of special concern are the delineation of urban areas, agricultural lands, mineral reservations, forests open to commercial exploitation, forests devoted to uses other than timbering, multiple purpose areas, wilderness and parks, and especially vulnerable air-sheds, drainage basins, land forms, soils, and ecosystems or subsystems. Planning should take into account the prospect of population growth, the fixity of space, and the probable demands and capabilities of future generations.

Energy, materials, and the environment—coordination is needed

4. A compatible national energy policy should be formulated in conjunction with a national materials policy. An energy policy should not be limited to evaluation and use of available supplies at home and abroad but should also consider controls on demand for energy consistent with the needs of a high quality natural environment. Federal legislation should be introduced that calls for coordination in development of energy and environmental policies and administrative actions.

Exploring for and extracting minerals—ecosystems must be protected

5. Exploration, extraction, and harvesting should be restricted to those occurrences and areas where damage to the surface of the earth and productivity of the ecosystem can be repaired or averted. As the technology of protection or reclamation advances, additional resources can be made available for development. In relatively few instances where marginal costs of repair are sufficiently high, some environmental damage may be tolerated. Legislation should be introduced directing agencies to establish environmental standards where these do not now exist.

Economic policy—use it to help protect the environment

6. Economic policies should be coordinated with policies designed to enhance the quality of the environment. Economic controls should be used to discourage production of goods and services that reduce environmental quality and encourage production of those that impose minimum environmental stress. Efforts should be made to stimulate longevity of commodity life, reduce stylistic obsolescence, and encourage use of materials and designs that facilitate recycling. Price regulations, charges for the use of public lands, tax provisions, and govern-

ment procurement, spending, and investment policies that now stimulate use of environmentally damaging materials at the expense of others less damaging should be abandoned except in the face of obvious national need.

National materials policy—administrative devices to protect the environment should be contained

7. A national materials policy should use those administrative devices that achieve the objective of protecting and enhancing the environment at least cost to society, [like emissions taxes; prohibitions; design or performance standards permits; subsidies; and direct government investment]. (pp. 24–27)

The study committee took a particular interest in the international aspects of materials-energy-environment policy and referred to the growing international concern with the issues epitomized by the United Nations Conference on the Human Environment held at Stockholm in June 1972. The report stated that:

> Internationalization reflects growing awareness of the detrimental effects of economic and technological development upon the quality of the environment, the adequacy of natural resources, and the threatened extinction of species. (p. 29)

The Stockholm Conference, the most comprehensive international action program on the environment up to the date of this report, adopted principles concerned with the protection and rational management of the earth's natural resources and environment, control of the discharge of toxic substances and heat, protection of the seas, the integration of ecological considerations in development planning, and the application of science and technology to the identification and control of environmental risks.

The study report also made 15 recommendations dealing with the responsible cooperation of the United States with other nations of the world in improving environmental conditions internationally along lines consistent with the recommended U.S. materials-energy-environment policies espoused earlier in the report. (See pages 31 through 32 of the report for the detailed recommendations.)

The report specifically recommended that the United States cooperate closely with Japan, and with other countries as appropriate, in regard to materials and environmental policy, particularly in regard to the growing competition between countries for desirable raw materials.

The report recognized that multinational corporations have a large impact in foreign countries and stated that these corporations should act responsibly in regard to the possible international environmental impacts of their operations. "The way in which multinational corporations can be induced to adopt practices that reflect a high level of concern for environmental quality when the host country does not impose environmental controls and when no public funding is entailed should be investigated as part of a national materials policy."

The study committee recognized an urgent need for basic research, research directed toward the solution of specific problems, the acquisition of basic data, and a monitoring network related to materials,

energy, and the environment. In fact, the report recommended increased research and development on practically every aspect of the materials, energy, and environmental issues discussed in the body of the report and stated that:

> The need for a major increase in research support can scarcely be overstated. If words such as "crisis" or "catastrophe" seem to be unscientific exaggerations of the nation's environmental state of health, it is only because of the faith that we have in technology and social measures to reverse trends that are now ominously under way. (p. 36)

Summary

In summary, the NAS–NAE study committee report stressed that there might be a fundamental human right to a quality environment and that materials-energy-environmental policy should be based on this premise. The ramifications of this stance would be that economic considerations were to be undertaken in line with the more basic environmental quality considerations. This would mean that the so-called external costs of economic processes, like environmental degradation, should be internalized, that is, paid for by the parties causing the costs. In practical terms, this philosophy would imply that the environment should be protected by assessing the polluters and despoilers, and that costs and prices of mineral processes and manufactured goods consequently were likely to rise. Moreover, this philosophy of environmental quality, as espoused in the report, meant that some costs of environmental protection would be too high to bear and that therefore some traditional components of national growth would have to be curtailed.

The report thus proposed a major reordering of national priorities toward environmental quality at the expense of traditional production processes and economic growth. To undertake and carry out such a program would require comprehensive national planning, management, and program implementation in the field of materials-energy-environment policy.

—Summary by William C. Boesman.

IX. NATIONAL MATERIALS POLICY

Summary of the Hearings Held Before the Subcommittee on Minerals, Materials, and Fuels of the Committee on Interior and Insular Affairs of the U.S. Senate, October 30 and 31, and November 1, 1973 [1]

These hearings were held under the chairmanship of Senator Lee Metcalf to discuss aspects of materials policy in light of the recently released report of the National Commission on Materials Policy, "Material Needs and the Environment: Today and Tomorrow." Although the witnesses had been asked specifically to comment on the NCMP report, most of the Government agency representatives focused instead on the current activities of their own agencies or on reports they had produced on the subject. Industry representatives chose to pick out the NCMP recommendations which would affect their particular industry most adversely, and to present their negative views. Topics covered by the NCMP which would affect industry favorably were also pointed out by these representatives. In fact, no witness, not even those from the universities, gave a complete critique of the Commission's report. Some new suggestions were received by the Committee on Interior and Insular Affairs concerning possible legislation. Trade association representatives suggested changes in trade laws; smelting industry representatives suggested changes in air pollution control laws; mining representatives suggested changes in the mining laws; and others recommended that new commissions should be formed to make further studies.

* * * * * * *

The Subcommittee on Minerals, Materials, and Fuels of the Committee on Interior and Insular Affairs met in late 1973 to discuss the report of the National Commission on Materials Policy [2] which had been issued in June of that year. The Chairman, Senator Lee Metcalf, noted that "Many of these [NCMP] recommendations deal with subjects under the jurisdiction of this subcommittee." The committee had asked their witnesses to "comment on the Commission's report," and to give their "recommendations for new or revised Federal legislation or administrative actions by Federal agencies under existing law." The Chairman further suggested that intensive consideration had already been given to energy policy issues, and that, at this time, the committee was "particularly interested in recommendations dealing with those aspects of materials policy which do not deal directly with energy."

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[1] U.S. Congress. Senate. Committee on Interior and Insular Affairs. Subcommittee on Minerals, Materials, and Fuels. National materials policy. Hearings, 93rd Congress, 1st session. Washington, U.S. Government Printing Office, 1973. 514 p.

[2] "Material Needs and the Environment: Today and Tomorrow," June, 1973.

The hearing's record contained a copy of Public Law 91–512, the Resource Recovery Act of 1970, under which the NCMP had been formed and which made provisions for the study under discussion in these hearings. Twelve witnesses were heard during the three days of hearings, representing the NCMP, various Federal agencies, universities, professional associations, and the materials processing industry. The areas of agreement/disagreement with the NCMP report raised by each witness are highlighted in the following sections of this report. Where pertinent, other statements made by the witnesses concerning national materials policy have also been included.

Jerome L. Klaff

Klaff appeared before the committee as the former chairman of the NCMP. The report under discussion had been produced during his chairmanship of the Commission. He stated that he was apearing "to provide the subcommittee with a summary of basic recommendations of the Commission," which had numbered 175. Klaff felt that the basic themes of the report of the NCMP were embodied in the letter of transmittal for the final report. These five elements of a materials policy were:

> 1. Provide adequate energy, and materials supplies to satisfy not only the basic needs of nutrition, shelter, and health, but a dynamic economy without indulgence in waste.
> 2. Rely on market forces as a prime determinant of the mix of imports and domestic production in the field of materials but at the same time decrease and prevent wherever necessary a dangerous or costly dependence on imports. This last phrase conforms with the previous act.
> 3. Accomplish the foregoing objectives while protecting or enhancing the environment in which we live.
> 4. Conserve our natural resources and environment by treating waste materials as resources and returning them either to use or, in a harmless condition, to the ecosystems; and
> 5. Institute coordinated resource policy planning which recognizes the interrelationships among materials, energy and the environment. (pp. 12–13)

Klaff used most of the remainder of his testimony to summarize the three basic "summary directives for policymakers [which] evolved from the Commission's studies * * *" (see summary no. VI. in this report) and to discuss some of the specific recommendations and data that had appeared in the Commission's final report. Concerning the three summary directives, he stated that they had encompassed "12 of the most urgent of the—175 recommendations—included in the body of the report." The NCMP document had not pointed this fact out, however.

During his testimony Klaff suggested that to meet the urgent new requirements for policy in the energy-materials-environment area, as spelled out in the NCMP report, "it will be necessary to write some new legislation, enact a number of statutes, some of which are already before the Congress, make important budget adjustments and write new Executive orders * * *". He further stated that the most important piece of legislation needed was that for the creation of a resources de-

partment. He urged the passage of S. 2135, pending at that time before the Senate, which would have established such a department.

With respect to land disturbances caused by mining activities, Klaff pointed out that the NCMP report documented that only 0.3 percent of the land surface had been disturbed by such activities "through U.S. history." He therefore concluded that "the task of keeping control of the disturbance is not an overpowering one."

On the subject of recycling, Klaff stated that "There has grown up a myth that if we would only recycle our solid wastes, we would solve our supply problems." He suggested instead that an even greater contribution would be made "if Congress would supply the incentive to obtain some of our materials from the urban wastes."

Klaff clarified during the questioning period that he did not see an actual confrontation between the "environmentalists" and the "developers." He said "They must be on the same plane or same level, working together. One is inseparable from the other * * *. There shouldn't be a conflict."

In a discussion on land use policy with the subcommittee members, Klaff was asked whether "Congress was mistaken in enacting the wilderness bill * * *." (The NCMP report contained an extensive discussion of the lands to be classified as "wilderness" and the potential impacts such classifications might have on the materials resource base.) Klaff was careful to point out that there was some merit to preservation of certain areas but that "If you tie land up for a specific purpose, before you know its relative value to the general public, you are possibly making a serious mistake."

The general theme of Klaff's testimony could be summed up in his statement: "the materials problems of this country are very large, very complicated, and their solution is urgent. Too many of them have been put aside to handle other problems."

Betsy Ancker-Johnson

Ancker-Johnson, the Assistant Secretary for Science and Technology, Department of Commerce, did not address the NCMP report in her testimony. Rather, she gave her impressions of the "national concerns that led to the study by the Commission," which included the shortages of materials and energy materials, environmental degradation, imbalance of trade, and a weakening domestic economy. She went on to discuss, in oral testimony, two issues which she felt required action immediately, and covered a third issue in her written testimony. The three issues were: supply of materials; measurement systems and the government-wide coordination of all R. & D. efforts in materials and energy.

Supply of materials.—Ancker-Johnson pointed out that three areas of R. & D. held "the most promise in insuring an adequate supply of materials: new energy sources, conservation and substitution." She went on to discuss these topics and pointed out that the Department of Commerce was conducting R. & D. in these areas. She did not suggest that any specific action be taken by the Congress on this subject.

Measurement systems.—The Assistant Secretary discussed three examples whereby measurement systems had/could result in considerable savings of materials. She felt that these examples served to emphasize

that "maintenance of an excellent system of measurements and standards is absolutely necessary for a succesful program of materials conservation," and pointed out the extensive role of the National Bureau of Standards in this area.

Government-wide coordination of materials R. & D.: Ancker-Johnson stated in submitted testimony that the "President's proposal to establish a Department of Energy and Natural Resources offers a real opportunity for bringing materials concerns together." She further noted that the problems were of such immediate concern, however, that organizations such as the Federal Council on Science and Technology, the Interagency Council for Materials, and the Environmental Resources Committee, had already begun to coordinate such efforts.

Ancker-Johnson was asked by a subcommittee member to study the Commission report and to "submit to the committee any specific comments—on the conclusions and recommendations." She agreed to do so but, if submitted, these comments were not included as part of the hearings' record.

Stephen A. Wakefield

Wakefield, the Assistant Secretary for Energy and Materials, Department of Interior noted that "there is a large area of common coverage and agreement between the report of the National Commission on Materials Policy and the current Second Annual Report of the Secretary of the Interior on Mining and Minerals Policy," and that "Many of the 177 recommendations of the * * * Commission [r]eport * * * are encompassed by the nine broader recommendations of the Interior report * * *." Thus, Wakefield stated that he chose to address both reports in his testimony.

The rest of the testimony of the Assistant Secretary concerned the major recommendations of the Secretary of Interior's report, and the activities of the Department of Interior which supported the Interior report recommendations. He pointed out that many bills had been introduced to the Congress in support of many of the Interior report recommendations and enumerated these.

The two important points raised by Wakefield were that "an extremely useful purpose could be served by the creation of industry advisory groups to be available for consultation by the Secretary [of Interior] on problems affecting the mining and minerals industries * * *" and that the Department of Interior envisions "the Bureau of Mines as the primary agency for developing ways and means to implement the Mining and Minerals Policy Act of 1970."

Wakefield concluded his oral testimony with the statement that "the work of the National Commission on Materials Policy has done much to stimulate public interest and concern regarding our materials problems, and the forward-looking Mining and Minerals Policy Act of 1970 points the way toward multiple-directed solutions."

During the questioning period, Wakefield was also asked by the subcommittee members to provide a "critique or analysis of this very thorough study put together by the Commission." If provided, these comments did not appear as part of the record.

When asked whether he supported equalization of the tax and subsidy treatments for virgin and secondary materials, as had been recom-

mended by the NCMP, Wakefield said he did not have either recommendations or comments at the time.

Arsen J. Darnay, Jr.

Darnay appeared in the capacity of Acting Deputy Assistant Administrator for Solid Waste Management Programs of the Environmental Protection Agency. He noted that the EPA believed, in agreement with the Commission's report, "that there are means and policies available to minimize the inherent conflict between materials supply and use, and protection of the environment." He further stated that it was "very encouraging that the Commission recognized the importance of striking a balance between the 'need to produce goods' and the 'need to protect the environment' and made definitive recommendations for achieving this balance."

Darnay called attention to the fact that the NCMP report had suggested the recovery of materials from solid wastes and greater efficiency of materials use as two of the means to strike a balance between materials supply and demand. He went on to describe the findings of the EPA "concerning the feasibility of and potential for satisfying part of our material demands through resource recovery and conservation of materials." The EPA had found that it would be possible to carry out resource recovery at costs comparable to and lower than conventional means of solid waste disposal. He stated that the largest single consumer product use category was in containers and packaging, accounting for about one-third of the total waste stream. The EPA suggested several options for materials conservation, therefore, which called for greater efficiency in packaging and containerization.

In the question/answer period, Darnay stated that it was not the view of EPA "at the present time that the Federal role in solid waste management should be extremely large or active." He also said that it would not be the opinion of the EPA "that mandatory product standards [for the reduction of materials use in products and processes] should be established" due to the controversy at that time as to what approaches should be used. Senator Buckley asked whether incentives or subsidies should be given to cities and States to encourage the building of resource recovery systems and Darnay replied that "At the current time * * * [the EPA did] not believe that incentives to municipalities are needed."

Charles F. Barber

Barber appeared on behalf of the American Mining Congress, a national association of those U.S. companies which produce most of the Nation's metals, coal and industrial and agricultural minerals. Barber noted that the Commission had suggested that "the country need not be torn between the goal of meeting national material and energy demands and the goal of minimizing environmental pollution." He seemed to be expressing agreement with this idea, but did not state this explicitly. He went on to discuss the existing air quality legislation, i.e. the Clean Air Act, and suggested three ways in which the American Mining Congress felt this Act should be amended, to remove undue burdens from the nonferrous smelting industries. The Congress felt that "the applicable regulations have focused on positive

controls beyond that necessary to achieve the compliance with the ambient air standards."

In discussion of the Land Use Policy Act, Barber stated that "this type of legislation should recognize mineral development as a primary and basic use of land and provide for a balanced recognition in the planning process of the essentiality of the continued production of minerals from the land."

Barber also addressed the topic of mining laws, suggesting that they were in need of amendment to establish clear titles to claimed mines in the public domain which have been abandoned. Barber did not think that existing mining laws were completely inadequate, despite complaints of past abuses, since "this is very largely a problem of the past, and with the perceptions that are now available and with legislation that restrains those few who would abuse the laws, mining can go forward without offending our current environmental perception."

Barber believed that legislators must remember that "man cannot take mineral wealth from the Earth and obtain its benefits without changing the Earth to some degree." He suggested that legislation should encourage and accommodate exploration and mining, not prohibit it.

In the questioning period, Barber discussed the minerals available from the seabeds. The organization he represented felt that an "interim regime" should be established to provide security of tenure to those U.S. firms which were willing to begin development of these resources. This was necessary, in his opinion, since the United Nations had tied up deliberations on this issue for a number of years.

Barber also expressed the thought, during this session, that the pricing system could be used to curb consumer demands.

Larry Cline

Cline, the vice president of the National Crushed Stone Institute, reported that that organization supported the view of the Commission that a balanced approach to the problem of developing mineral resources and protecting the environment must be sought. The institute was "afraid that if the scales are tipped too heavily in favor of the environment, regardless of the consequences, as appears to be the trend, that the end result would be a severe retardation of our Nation's social and economic progress in which minerals have played a key role."

Cline strongly disagreed with the Commission's position on existing environmental legislation, however (that such legislation was not extensive or powerful enough to induce the desired social responses), stating that this recommendation was "ill-advised and would further tip the scales."

Generally, Cline was in agreement with other aspects of the Commission report. He supported the NCMP statements on land use policy and was especially appreciative of the Commission's recognition of the limited land surface affected by mining. He described the NCMP report as "a valiant effort at tackling a very complicated problem."

John Muench, Jr.

Muench testified in his capacity as director of economics for the National Forest Products Association. While Muench commended the

Commission for "both their conscientious effort and their final report," he noted that "application of many of the recommendations will first require more specific studies on various materials."

Muench discussed a recent study of the National Forest Service, "The Outlook for Timber in the United States," which could serve to provide additional information on this renewable resource. He noted that policy actions needed to take advantage of timber opportunities were discussed in that study, and that they were in agreement with some of those mentioned in the NCMP report.

Another recent study by the President's Advisory Panel on Timber and the Environment was referenced by Muench. He said that this study had drawn conclusions similar to those of the NCMP.

The National Forest Products Association, according to Muench, fully endorsed the recommendation of the NCMP to establish a temporary Natural Resources Coordinating Committee, and to develop "analytical and advisory capabilities for addressing national materials policies and programs in the context of the total materials cycle and the associated energy and environmental requirements."

David J. Steinberg

The Committee for a National Trade Policy was represented by its executive director, David J. Steinberg. He stated his agreement with the NCMP recommendation that market forces should be used to determine the mix of imports and domestic production, subject to certain considerations of public policy with regard to national security, health of domestic industry, and fair international competition.

Steinberg went on to point out that there were serious faults in the present trade policy, with respect to government involvement, and said that "neither present practice nor the report of the [NCMP] warrants * * * [an] * * * optimistic * * * prognosis * * *." He felt that there were no clear efforts on the part of the government to provide "constructive assistance to ailing industries * * *." He made the strong statement that "No import restrictions or any other kind of government help should be given an industry except through * * * a coherent policy framework." Such a policy would establish the costs to consumers and the Nation as a whole, both direct and indirect.

Steinberg believed that the lack of a coherent policy led to actions which did not directly impact on the actual problems of industry. He cited the fact that the government has a textile trade policy, but no textile policy, and a steel trade policy, but no steel policy. He supported the reforms proposed by the NCMP "regarding the administrative pattern of executive and congressional attention to materials policies" since they "would be helpful in insuring the coherent, coordinated approaches so urgently needed."

Steinberg also discussed the issue of relations with less-developed countries where much of the world's raw materials resources are located. He suggested that there was a "need for the industrialized countries, to open their markets to the complete range of exports from the less-developed countries as quickly as possible." He felt that "there is rhetoric galore about this. But as in so many other aspects of public policy, our commitment and followthrough are not where our rhetoric is."

Gordon J. F. MacDonald

MacDonald, the Henry Luce Professor of Environmental Policy and Studies at Dartmouth College, (and formerly with the Council on Environmental Quality) described the NCMP report as "provid[ing] * * * the Congress [with] a number of very far reaching and innovative recommendations for the future." He felt the "single most important statement in the Commission's report" was the policy directive to strike a balance between the "need to produce goods" and the "need to protect the environment." He supported the Commission's thesis that the user should pay and felt that the NCMP recommendations to institute taxes or user charges on pollutants emitted into the environment was basically sound.

MacDonald went on to state that resource recovery was a very important issue, and confined the rest of his testimony to this topic. He stated that "a significant feature of the report of the National Commission was that it documents the environmental dividends that result from resource recovery." He discussed the three possible barriers to effective usage of secondary resources: technological, institutional, and economic. He concentrated on the latter of the three and proposed that the Congress consider the institution of a "tax incentive to encourage the private sector to become involved in recycling of waste material and make solid waste and resource recovery more profitable and competitive with current means of disposal." MacDonald presented the specifics of his proposal, and what materials should be included in the tax incentive program. He also presented some calculations to illustrate the benefit/cost ratios for such a program using three sample materials.

The final topic addressed by MacDonald was the threat of increasing quantities of toxic materials which were entering the waste stream as constituents of other products. Such things as the mercury in batteries, and other potentially toxic materials in discarded products posed a real threat to the environment in the future, according to the witness. MacDonald suggested that a deposit on such things as batteries could assure that most of these are returned to the manufacturer or other agent who could dispose of the toxic materials properly.

Charles S. Dennison

Dennison had served on the National Academy of Science's Committee which produced the report, "Man, Materials and Environment." (see summary no. VIII. in this report) He was, at the time of the hearings, the senior advisor for international industry to the United Nations environment program. Dennison referred to a statement made by Maurice Strong, of the United Nations which he submitted for the record. In this statement, Strong said that "relentless application of purely economic criteria to decision-making has grossly distorted the allocation of resources in favour of the areas of highest economic return rather than of social priority." Dennison expressed his agreement with this sentiment, and said that this "distortion of values has not only occurred in the United States but is a severe problem throughout the industrial world." He noted that the pressure on resources due to such a trend would be immense and indicated that the Commission had also recognized the potential pressure in their report.

Dennison stated that he agreed with the policy directive of the NCMP that there should be a balance between the "need to produce goods" and the "need to protect the environment." He only partially agreed, however, with the directive of the NCMP that conservation of materials and accelerated use of recycling would help attain an equilibrium between supply and demand of materials. He said, "The statement is fine, but I don't believe it goes far enough." He thought that the Nation should initiate an "imaginative search for technologies and industrial practices that are dynamic yet do not punish man and his environment."

Dennison supported the third policy directive of the Commission, to manage materials policy more effectively.

Taken as a whole, he felt that the NCMP recommendations were consistent with those of the National Academy of Sciences in its report, but that "the largest differences lie in the area of supply versus demand." He indicated that the NAS had been more concerned with the "conviction that more attention should be paid to the question of curtailing or shifting demand * * *." He described the economy of the United States as a "huge machine" geared toward growth, consumption and use of materials, and suggested that a "series of forces and influences must be mobilized under Presidential and congressional leadership * * *" to induce an alteration in the economy. He felt that three areas would require action: the industrial community would need to expand their research efforts; the government could use tax and other incentives to achieve results; and public opinion could be mobilized to institute a force on the market and on public policy.

J. Kenneth Klitz

Klitz was a former member of the staff of the National Commission on Materials Policy and appeared at these hearings in that capacity to discuss the environmental factors in materials policy and the inventories of materials.

He stated that he "supported the main thrust of the Commission's report—that resources, energy and the environment be treated in total; that pollution and the depletion of resources are caused by the failure to manage the flow of materials as a cycle; and that the objective is to find the optimum balance between the consumption of materials and the preservation of the environment * * *." He noted a number of recommendations of the NCMP which he specifically supported, most of which dealt with the environment. Klitz was not representing a particular organization, but was presenting his own views.

Klitz also commented on the section of the Commission's report dealing with inventories of materials. He described existing systems, all of which had been described in the NCMP report and the efforts underway in other nations. He made a number of recommendations concerning the specifics of how such an inventory system would operate once established.

Charles J. Ryan

Ryan had been the assistant director for policy development with the National Commission on Materials Policy. He presented in his testimony, some of the fundamental changes which have taken place in the physical world and which have impacted significantly on the

Nation's materials stance. Most important of these changes was the new role of "energy" in man's life:

> In modern times man's energetic relation to his environment has changed, for he now has much more fuel under his control, and it enters through a different route. Man's new industrialized system now derives its energies from the flows of concentrated fossil fuels, coal, and oil. Much of this energy flow is put back into his environmental system so that his yield of food and critical materials is greater.
>
> Only a small part of the total controlled energy is now processed by the individual person or by work that is recognizably personal. More and more of the energy flows are in machines of the system. We may wonder whether the individual human being understands the real source of the bounty to him of the fossil fuel subsidy. How many persons know that the prosperity of some modern cultures stems from the great flux of oil fuel energies pouring through machinery and not from some necessary and virtuous properties of human dedication and political designs? (p. 354)

He continued that "man's role in the environment is becoming so enormous that his energetic capacity to hurt himself by upsetting the environmental system is increasing." He felt that energy was a "prime physicial mover" which could either "liberate or imprison." Ryan thought that a strong national development policy would be needed and suggested formation of a commission to produce a "well-thought-out" report on this subject.

—Summary by Carol Lee McBee.

X. THE NEED FOR A NATIONAL MATERIALS POLICY

Summary of Hearings Before the Panel on Materials Policy, Senate Committee on Public Works, June–July 1974 [1]

Although these hearings before the Senate Committee on Public Works, Panel on Materials Policy, were addressed to the broad need for a national materials policy, primary emphasis was upon one element of such a policy, namely, the need for increased resource recovery and recycling. Senator Jennings Randolph, Chairman of the Panel, set the general tone of the hearings in his opening remarks by pointing out that "it is now feasible at least in part to simultaneously cope with the problems of waste, energy, and materials under one umbrella." [2] These sentiments were echoed by other members of the panel who drew attention to the need to extract both useable materials and energy from municipal solid waste [1:5], to protect the Nation's health and environment while doing so [1:6], to use such procedures to help reduce the Nation's dependency upon foreign resources [1:19], and thereby also to help solve what most American cities consider their most pressing problem: the disposal of municipal solid waste [1:17].

* * * * * * *

During ten days of hearings testimony was received from 40 primary witnesses (see Appendix to this report in which witnesses are listed) accompanied by an additional 27 persons, many of whom provided supporting testimony. Witnesses represented 39 groups and agencies distributed as follows: industry, 9; State and local, 7; labor, 6; civic and nonprofit, 6; citizen action and environmental, 5; industry professional, 4; and Federal, 2. Testimony, plus supporting material, ran to 2335 pages of published material in three volumes.

Throughout these extensive hearings, almost all aspects of resource recovery and recycling were explored. For convenience, the topics discussed can be considered as (A) broad, topical areas or (B) specific problem issues. These areas and issues are summarized separately below.

BROAD TOPICAL AREAS

Four prevailing themes consistently arose throughout much of the testimony: the Federal role; the State and local municipality role; possible alternatives in the management of solid waste; and the potential role of source reduction. Each of these themes is summarized below.

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[1] U.S. Congress. Senate. Committee on Public Works. Subcommittee on Environmental Pollution. Panel on Materials Policy. The need for a national materials policy. Hearings, 93d Congress, 2d session. In three parts. Washington, U.S. Government Printing Office, 1974. Part 1. June 11–13, 1974, pages 1–460. Part 2. July 9–11, 15–16, 1974, pages 1–782. Part 3. July 17–18, 1974. pages 783–1875. 2335 p.

[2] Part 1, page 3. All subsequent references will be given within the text, indicating Part Number followed by page number, as follows: (1 : 3).

The Federal role

Many witnesses called attention to the responsibility of the Federal Government to help solve solid waste problems, and also to the need for Federal leadership in this area. It was pointed out that "the formulation and introduction of a new materials policy is a proper function for the Federal Government [which] has been largely responsible for our present cheap materials policy, and thus it has some responsibility for thinking through the merits of alternative materials policies." [1:23] Although recognizing that "It is at the local level that the solid waste battle must be fought." [2:1] it was pointed out that what was "sorely needed" was strong Federal leadership to insure that "resource recovery technology is coordinated and does not develop in a haphazard manner, coupled with financial incentives for States and local communities to move toward resource recovery." [2:387] Congress, it was felt, "must act to stimulate a more complete application at the municipal level." [3:820] As an example of the lack of Federal-level coordination, it was pointed out that "it is not uncommon for a federally funded project such as a highway or a water and sewer improvement program to condemn land occupied by a recycling industry. In such a case, the scrap yard often finds itself zoned out of existence." [3:821] Despite this generally-recognized need for Federal involvement and leadership, several witnesses noted that, other than for hazardous wastes, the then-existing administration "continues to oppose Federal involvement in solid waste planning and separation * * * a situation we find most disappointing," [1:131] and "The Federal Government has minimized and ignored the problems and potentials of solid waste, and this administration's present approach appears to perpetuate this low priority." [1:137]

Additional reasons given for a strong Federal role in resource recovery and recycling included the Nation's dependency upon foreign supplies for many necessary materials, the need to increase the general rate of recycling activity, and the need for additional data regarding both resources and resource recovery. "The energy crisis has shown how dependent we are on large quantities of imported energy materials," one witness stated. "People are beginning to ask if what happened with oil could happen with other materials * * * it is likely that much of the attention that has recently focused narrowly on energy materials will broaden in the next few years to encompass materials in general." [1:21] This witness predicted that "we are in for a period where efforts at cartelization will be more successful than they have been in the past." [1:33]

It was clear from various testimony and discussion that ultimate recycling goals varied from material to material and were largely in doubt. For example, one witness commented with regard to ferrous scrap that "I would never advocate * * * that we try to recycle all the scrap. It would be too costly." [1:59] On the other hand, a spokesman for the aluminum industry expressed optimism that the industry might "achieve our goal, which is the total recycling of all used aluminum consumer products." [2:388] A further problem raised was the lack of information to effectively plan ahead for both primary and secondary materials utilization. It was suggested that "We would be far better off if we had better information as to what reserves become available at what prices and at what environmental costs * * * we

should also do better in the way in which we estimate reserves. In the past these estimates have been without much regard to the price at which they might be extracted and the environmental cost that may be associated with the extraction." [1:39]

The State and municipal role

An Environmental Protection Agency (EPA) spokesman pointed out that an "element * * * integral to a viable waste management and resource conservation program is a strong and effective State and local program" [3:1069] and that "Forty-four States have completed approved solid waste management plans." [3:1067] However, he later admitted that "the level of effort within the States and localities is quite low and more will be required to really develop those requirements and fully enforce them." [3:1131] Most witnesses who discussed the efforts of State and local municipalities agreed that Federal aid for these efforts was both desirable and necessary, but considerable disagreement existed as to the specific form this help should take.

Perhaps the greatest area of disagreement was whether the Federal Government, through the EPA or otherwise, should directly fund or provide loan guarantees for municipal resource recovery facilities. Understandably, State and local government officials tended toward the view that "the Federal Government should stimulate the development of resource recovery facilities at the local level," for example, through "below market interest rate loans * * * for 100 percent of the cost of facilities construction." [1:136] However, some local officials were concerned that widespread Federal aid of this kind might result in premature efforts that would later be regretted. They recommended that any Federally supported programs be spread over 5 years "with at least the first 2 years being used solely for planning and feasibility studies and the next 3 years being used for implementation," and furthermore that funding be given "only to those plans, projects, or programs which truly maximize energy and material conservation, while attempting to minimize environmental and economic costs." [2:216]

Other witnesses were convinced that no "massive Federal funding of demonstrations is wise or necessary at this time until the current efforts are evaluated and so long as private enterprise and private capital continue to flow to this area of endeavor." [3:852] Indeed, it was concluded by some that "the existing sources of private capital are sufficient to meet the goals and objectives that will occur as a result of increased market demand." [3:1018] Furthermore, there were "wide ranges of financing alternatives available to States and municipalities including general obligation bonds, municipal revenue bonds, pollution control revenue bonds, leasing, and private financing." [3:1070] As seen by these witnesses, the Federal role should be restricted to "vigorous Federal * * * training and education, planning, and technical assistance to State and local governments." [3:852]

Possible management alternatives

A major reason enunciated by several witnesses for proceeding cautiously in the construction of large-scale resource recovery facilities was that it was as yet too early to determine the optimum character of such facilities. As one witness stated, "there is a danger that if a large Federal subsidy program existed today to accelerate the applica-

tion of the programs that we currently know about that are still in the early phases of implementation, there is a risk of cities selecting the wrong kinds of projects to suit their needs. We are about 2 years away from having the data available to evaluate the best type of technology for various applications in various cities." [3:1021]

It was clear from much testimony that perhaps the most popular choice of facility by local municipalities was that built for conversion of waste to energy. Clearly, once such facilities were a reality, there would be little incentive to recover combustible materials for recycling as materials. Indeed, a considerable disincentive would have been created, as postulated by Sen. Domenici: "A major metropolitan area sets up a conversion plant requiring x tons of conversion materials * * * [as the] capacity of that plant * * * [grows] the requirement * * * [grows and] we might in lieu of taking out paper and using it as a reuse paper * * * be stuck with the proposition of burning what we could reuse." [3:413]

As suggested by one witness, "We don't want to see us go down the path of producing electricity from materials that could be recycled, reused, or maybe not even generated in the first place because the analysis shows that that is not the most efficient way to treat these materials." [3:224–5] Thus, according to another witness, "it is crucial to determine whether it is better to recycle or burn or pyrolyse solid waste and how much of the combustible component might ultimately be economically recycled, reused, or removed from the solid waste stream." [3:218] In effect, as pointed out by still another witness, only those "Wastes which do not warrant materials recovery efforts as indicated by * * * cost/benefit analysis, should be disposed of by methods that encourage energy recovery." [3:451] One witness expressed skepticism as to the integrity of some resource recovery efforts, stating that "As a matter of fact, we are concerned that many of the efforts directed at encouraging the recovery of materials from waste may be undertaken to circumvent the possibility of source reduction programming." [2:683] Hence it was urged that "a thorough investigation of potential for resource conservation and materials recovery be the first priority in evaluation of any energy recovery proposals under consideration for funding." [3:686]

Potential role of source reduction

Quite apart from the question of how best to make use of solid waste was a question posed by many witnesses: how to reduce the quantity of solid waste in the first place. Many felt that this was the fundamental problem, as "It does not make sense to start with resource recovery and then work toward source reduction because the centers themselves will be used as an argument against ever reducing solid waste at the source. Capital-intensive machinery must be fed." [2:218] Another witness called source reduction "the key to solid waste management that attacks and addresses itself to the problem—the generation of waste—and doesn't just try to cover the symptoms by attempting to determine what to do with waste once we have it." [2:709]

Industry spokesmen pointed out that the concept of source reduction was by no means new, and that "industry has practiced 'source reduction' through more efficient use of basic materials for decades." [2:372] Conservation practices in industry have been such that "less

than half the iron ore, coal, limestone, energy and other basic resources are needed today to make a single steel beverage can than was needed 20 years ago." [2:373] Competition in industry has continued to foster source reduction practices. For example, beverage cans first developed in the early 1930's were made of 95-pound plate in the side and 103-pound plate in the lids. [2:510] Competition from aluminum can producers reduced the steel can to 55-pound plate, then fostered introduction of a lighter welded side seam, and then use of a plastic bonding material. These developments, in turn, promoted similar advances in the aluminum can industry: from 55 pounds of aluminum to produce 1000 cans to 39 pounds, then 34, 28, and even 26 pounds per 1000 cans. [2:510–11] Similar weight reductions, and consequent savings in materials usage, were achieved in nonreturnable glass bottles: from 8 ounces in weight to 7.5, 7, and finally 5.25 ounces [2:511]

In general, industry spokesmen testified that source reduction incentives were unnecessary and could actually be harmful if mandated by the government. Some felt that source reduction was "a negative approach to the problem as against the positive concept of resource recovery." [2:383] Others worried that source reduction "would result in reducing employment and economic stability, and will not solve the country's solid waste problems." [2:392] Thus, one witness concluded that "The entire concept of source reduction * * * may be premature at this time." [2:648]

For the most part, EPA spokesmen tended to favor the industry attitude, maintaining that "source reduction can be brought about through natural market forces provided by consumer choices and voluntary industrial action." It was pointed out that the EPA program of source reduction "has included providing information to consumers and technical assistance to industries in order to promote voluntary actions in this area, while at the same time continuing to study the need for legislation." [3:1069] The EPA view was that "this whole area of source reduction is preeminently one in which we are beginning to understand some of the potential. It depends very much on the specific material and economic factors related to individual products. It is impossible to take an approach to source reduction in one area and apply the same theory universally to other areas." [3:1136]

Those favoring source reduction expressed concern that the concept might be neglected in any legislation that the Congress might pass. As expressed by one witness, "given the materials policies we presently have, solid waste problems require a multifaceted approach * * * legislation passed by the Congress must look at all of these approaches and not exclude one of them. Our greatest fear is that the approach that potentially could be excluded is that of source reduction." [2:736] Another witness pointed out that "It is certainly inefficient from the legislative viewpoint to promote resource recovery without parallel emphasis on waste reduction." [2:757] Witnesses were assured by Sen. Domenici, however, that "any effort by the U.S. Congress which doesn't have both a strong effort at conservation along with a reasonable effort at turning into energy that which we for the foreseeable future envision as being a waste, I think any effort short of those two would provide chaos and certainly would promote further abuse of the raw materials that we are trying to conserve." [2:222]

SPECIFIC PROBLEM ISSUES

The major specific problem issues raised by the witnesses included: the issue of nonreturnable beverage containers, the lack of suitable markets for recycled materials, packaging standards, disposal charges, guidelines and standards, and the disposal of hazardous wastes. Testimony regarding each of these issues is summarized separately below.

Nonreturnable beverage containers

Witnesses universally agreed that used beverage containers littering the landscape were undesirable, but disagreed as to what might be done about it. Testimony was presented to show that much can be accomplished by banning use of nonreturnable containers, as was done in Oregon, on the basis that these containers are the ones most likely to end up as litter. The case against such containers was summarized by one witness as the "Seven Deadly Sins of the Throwaway Beverage Containers."

> 1. Waste enormous energy over returnable containers. The equivalent energy loss 5.5 million gallons of gasoline per day.
> 2. Squander the Earth's resources in such a fashion that recycling can never catch up.
> 3. Are a major contribution to environmental degradation.
> 4. Are an economical loss to consumers and the Nation.
> 5. Are an increasing factor in solid waste problems.
> 6. Have caused employment losses * * * (Big bottlers moved farther away from their markets and small bottlers have gradually gone out of business, with a consequent loss of jobs.)
> 7. They are a major factor in litter. [2:749]

Many witnessses, however, testified in favor of continued use of such containers. One witness attacked the container-ban concept as "symptomatic of a sickness in America that we had better begin to do something about. That sickness is negativism, sophisticated, cynical, suspicious negativism. Being against things, being against people, tearing down, accusing * * * 'No-growth' thinking and 'legislated living' will make America sterile in the end." [2:501] Another witness claimed that banning nonreturnables was not only ineffective but costly, as well. "It has been clearly established," he said, "that litter begets litter and that much of the litter that prompts the thoughtless disposal of beverage containers stems from mess that should have been and will have to be cleaned up in any case before behavior patterns can be changed * * *. To spend $5 billion to achieve relatively limited benefits would be to squander precious funds that could be better used to improve our environment in other, far more important problem areas." [2:532]

Some beverage manufacturing spokesmen maintained that there really was no choice as to the kind of container they could use, as this was dictated by the consuming public: "(I)ndustry is and always has been committed to packaging products in the manner responsive to the consumer needs and desires * * * manufacturers have geared their operations to the consumers' desires, our economic health is dependent upon certain packages being marketed in the United States." [2:505] Furthermore, they maintained that use of returnable beverage containers involved considerable added expense, both in plant capacity

and in labor costs. For example, "a system that produces 5 million barrels of beer in its normal packaging mix today, cans, returnable bottles, and nonreturnable bottles" requires about 465,000 square feet of floor space; conversion to returnable containers only would require about 1,400,000 square feet of space and an expenditure of $81 million. [2:506]

This, according to the witness, is because

> * * * bottle lines are not as fast in production as our can lines nor do they have the same efficiency because bottles break and cans do not * * * [I]n packaging cans and nonreturnable bottles we can regulate the flow of the containers from the manufacturer to the brewer * * * we have on hand at any one time 3 hours supply of empty cans. In the case of nonreturnable bottles * * * [w]e must keep a 3-week supply of bottles on hand * * * because we can't regulate the flow * * *. How many of us in our garages at home have three and four cases of either empty beer bottles or soft drink bottles on hand? We take them back when we want to take them back, not when the brewer or the soft drink bottler needs them. [2:507]

With regard to labor costs, a witness pointed out that a delivery truck currently delivering a typical 600 cases of beverages a day consisting of 300 cases of cans, 200 cases of nonreturnables, and 100 cases of returnables could at best deliver 250 cases of returnables during the same period, thereby more than doubling delivery costs. [2:508] Furthermore, "When you paid driver-salesmen $1 an hour and paid helpers 50 cents an hour, you could allow them to spend a half hour in the backroom of the tavern picking up bottles and putting them in cases. But when you are paying driver-salesmen close to $8 or $9 an hour, there is no way economically that you can allow all of our containers to be put in returnable form." [2:509] Only one beverage industry spokesman testified in favor of returnables, stating that "if this energy and materials thing is actually serious, then I say the beverage industry and other packaging industries are on a collision course with destiny. The glass plants are short on soda ash. They are also short of silica * * *. [O]ne-way bottles * * * are * * * lost forever if we cannot find some way to recover, recycle, and reuse [them]." [2:503]

Labor spokesmen were universally against banning of the nonreturnable container, largely because of the possible loss of jobs. "We are not against reuse," said one witness. "We are against doing it by compulsion." [2:594] Another witness viewed such a ban as unfair: "Aluminum cans have been included as a nonreturnable container and employees whose livelihood is dependent upon the manufacture of aluminum cans are being threatened instead of those guilty of littering." [2:630] Other typical comments included the following: "In the can industry alone we figure there are 45,000 people who would be affected." [2:591] "Proponents of bills to eliminate nonreturnables have agreed that many well-paying jobs would be eliminated if nonreturnables were eliminated. They have suggested that this be done over a period of years to 'ease the pain' to those senior employees who would lose their jobs. This is like cutting your throat with a dull knife." [2:638] "We most vigorously oppose * * * [banning nonreturnables which]

could lead directly to severe consequences in terms of job loss in return for relatively minor benefits." [2:645]

Lack of markets

Many witnesses commented upon the fact that adequate markets for recycled products do not exist, and ventured reasons for this lack. As one witness stated, "What is required to accelerate recovery is * * * a greater demand for recovered resources." [3:1009] Or another: "The current problem as I see it is lack of market demand." [3:1008] It was pointed out that recycling was "a little bit like the cream and milk story, what is being recycled now is the cream, industrial waste. When we get to municipal waste, we have an unknown element. Those materials which obviously are of lesser value which have never been tested in the marketplace * * * what plants are going to absorb them? * * * What we have in this country are laws and policies that are continuing to build a virgin material ethic. What we really need now are policies which will encourage a recycle ethic." [3:856] Considerable attention was given by witnesses to the fact that municipal wastes are given low priority by users, that:

> to date the primary sources of secondary materials have been commercial and industrial wastes. The reason being that volumes of these wastes are more than sufficient to meet current market demand for secondary materials. These wastes are also generally of a higher quality and more readily accessible than materials found in household refuse. Therefore, until market demand exceeds the current supply of secondary materials readily available from commercial and industrial wastes, it will continue to be more difficult to undertake the extensive and costly processing necessary to recover paper and metals from household wastes on national basis. [3:1000–1]

Despite the above, several industry spokesmen contended that—at least in some instances—lack of markets was no problem. A steel industry spokesman maintained that with regard to ferrous waste, "Our industry—and, we believe, others such as aluminum and glass—will guarantee to provide markets for these recovered resources whenever they become available * * *. I think there is no question about our being prepared to purchase and recycle all ferrous product separated in these reclamation centers * * *. [S]imilarly throughout the country the steel industry stands prepared to make agreements, binding agreements." [2:369, 377] Similarly, an aluminum company spokesman testified, "We are also making, today, commitments for the purchase of recovered aluminum which will provide these resource recovery systems with a ready market for their scrap. The other major aluminum companies are also providing markets for this material." [2:389] And a glass industry spokesman declared that "our industry has entered into well over 100 agreements to purchase the glass component from resource recovery facilities * * *. [T]echnically, the glass container industry can utilize an almost unlimited percentage of reclaimed glass in the batch material from which bottles are made, provided the reclaimed glass is of good quality. Practically, it is a matter of economics. Reclaimed glass or cullet must be priced competitively on a delivered basis with virgin raw materials." [2:390–1] A spokesman for the paper

industry also expressed optimism, stating that "Most of the paper mills in the United States are equipped or are becoming equipped to use secondary fiber or recyclable materials." [2:384] However, he pointed out certain difficulties in marketing paper waste.

> Looking at resource recovery of the paper fraction of solid waste, it is important to understand that there are two major categories of postconsumer waste paper. The first category is paper usable for recycling. Such paper must be clean. For this reason it must be collected separately and be uncontaminated by household and other refuse. The second category includes those paper wastes which have become contaminated, or have no economic recycling value. These wastes, however, have great potential value as an energy source. Resource recovery * * * requires a three-stage approach. First, separate the recyclable grades of paper from municipal solid waste. Second, extract the metals and glass from the remaining waste. Third, convert the balance to energy. [2:384]

Spokesmen for the secondary materials industry were not as sanguine as were the consumer industry spokesmen quoted above. "The iron and steel scrap processing industry," said one, "firmly believes that viable and continuing markets for ferrous scrap do not exist. For example, the reservoir of obsolete unprocessed ferrous scrap today is far in excess of 750 million tons. This reservoir cannot be marketed at a rate which will substantially reduce this backlog." [3:784] Furthermore, concern was expressed by secondary materials industry representatives that widespread municipal entry into resource recovery, and the marketing of recovered products, might subject them to unfair competition. They asked that the industry be allowed "to continue doing what we have been doing for years and that the proper concern with solid waste not be turned into a program that seriously impairs an existing industry and replaces it with a government subsidized program yielding less in public benefits at higher costs than the present system." [3:784] They maintained that if a public disposal system were "to siphon off material traditionally acquired by the recycling industries, the disposal system is impinging on the legitimate role of private enterprises * * *. [A]ny legislation adopted * * * should provide that no solid waste treatment and disposal center either receiving direct or indirect Federal assistance under the act may seek to acquire, for processing, materials not collected in the normal garbage and waste collection process for the areas served by that center." [3:788]

Packaging standards

Several witnesses, primarily representing environmental or local government groups, recommended that packaging standards for consumer products be developed by the Federal Government as a specific incentive to promote increased source reduction. The U.S. Conference of Mayors, for example, urged "the Federal Government to enact and effectively implement laws which would: require that all beverage containers in interstate commerce be returnable beverage containers, encourage the use of standardized containers, and eliminate the use of detachable openings in metal containers." The Conference recommended that "Such regulatory measures shall be accompanied by ample incentive for the return of deposit containers" and, furthermore,

that "the Federal Government should establish design, packaging, and product standards which will effectively provide for the reduction of energy consumption and environmental degradation." [1:143] A representative of the National League of Cities recommended that "The Federal Government should impose taxes on, regulate, and where necessary prohibit packaging and other practices which aggravate solid waste management difficulties. [I]f each individual used no more packaging in 1972 than he did in 1958, we could have saved 600 trillion Btu's, the equivalent of 300,000 barrels of oil per day." [1:131–2] A spokesman for the National Association of Counties pointed out that not only was "some form of Federal product standard control with firm packaging guidelines" needed, but that a vital element of this control was "a timetable by which these standards must be met." [2:253]

Industry representatives indicated that, for the most part, packaging was not an area into which the Federal Government should intrude, and furthermore that packaging was largely dictated by the marketplace. One industry spokesman pointed out that "the consumer is in the best position to take account of * * * how important is this convenient packaging that we, as the producers, who are involved in the production side conceive to be extremely important to our way of life." [2:407] Another industry spokesman maintained that "the consumer is a good and very definite judge of whether or not this package is necessary or whether some alternative packaging media will satisfy their needs." [2:407] Part of the packaging problem as seen by industry was that "inadequate consideration has been given to the constructive role which current packaging techniques play in our society." [2:456]

Disposal charges

Another specific incentive recommended to promote increased source reduction and more efficient packaging practices was the institution of product disposal charges which would reflect "the nonmarket cost of disposal" of such products. However, it was pointed out that although a product disposal charge has "considerable merit in theory, it is an administrative burden to collect a disposal charge on every physical product at the point of its manufacture. It may be more feasible to collect such a charge earlier, in fact, all the way back at the mine's mouth. Such a charge would be like an import tariff collected at the material ports of entry in the economy." Benefits cited for such a disposal charge were that "it would lead us to a more material and energy-conservative economy; it would encourage designs for greater product durability; and it would stimulate technology to use our materials and energy to squeeze out more product value per unit of material and energy." [1:30] Thus, another witness suggested that such charges might well provide "that kind of corrective pressure which just can't really be provided very well by a strict product standards approach." [2:715] It was suggested by still another witness that such charges might exert a considerable effect upon the education of consumers, since "you are asking the people to put an overall life cycle price on this material, and when people see that and the price contains that disposal price then they will understand more." [2:761]

Guidelines and standards

Much testimony concerned the need for Federal legislation to establish waste disposal guidelines and standards that would apply uniformly throughout the entire Nation. One witness testified that "The single biggest solid waste challenge is to close the dumps. This action not only would end the pollution associated with dumping, but it would force * * * [municipalities] up the cost curve and the technology curve and make resource recovery a much more competitive alternative." [3:831] He went on to point out that "The single most important action which could be taken to achieve * * * [resource recycling] goals is the establishment and implementation of solid waste disposal standards." [3:851] At the very least, one witness testified, "The Federal Government can play a role by defining minimum standards that should be followed by the States." [2:469]

Several witnesses commented upon the form that federal standards should perhaps take, for example, at a minimum to "Prohibit open dumps; regulate hazardous wastes, and control the impact of solid waste on other environmental components." [1:131] Another witness felt that Federal standards should govern "the disposal of wastes via landfill and incineration, and the prohibition against open burning or dumping of solid wastes." [2:450] Senator Domenici called attention to the fact that most of the bills under discussion "explicitly include procedures for enforcing * * * standards and regulations, and deadlines for putting them into effect." Indeed, he noted that "It was this combination of standards and deadlines which made the Clean Air Act an effective instrument of public policy." [2:4]

Hazardous wastes

Many witnesses emphasized the need for special consideration to be given the disposal of hazardous wastes "despite the fact that they constitute only a small proportion of all solid wastes." [2:462] Part of the problem, as explained by an EPA spokesman, was that many hazardous wastes "are simply mingled with other wastes and disposed of at general purpose disposal sites at which no special efforts are made to protect against the kind of damage that can come from hazardous wastes * * *. Our objective is to try to segregate these hazardous wastes and either treat them or dispose of them at sites which are specifically designed to handle these wastes and at which precautions have been taken to prevent leaching, fires, and other hazards." [3:1139]

However, witnesses noted that it was difficult at times to precisely distinguish between those wastes which are hazardous and those which are not. As pointed out by an EPA spokesman, "The term 'hazardous' is a term with very elastic meaning." [3:1141] As another witness noted, "One essential element of a regulatory program for disposal of hazardous wastes on land is that there be clear definition of the terms 'waste' and 'hazardous waste'." [2:463] An industry representative noted that "all substances in some quantity could be hazardous." Hence, he recommended that "the definition of hazardous waste * * * consider the quantity and degree of toxicity * * * when disposed of in the environment." He suggested a definition as follows: "Hazardous waste means any waste or combination of wastes which, after they have been disposed of, the [EPA] Administrator finds will cause serious adverse ef-

fects on human health, animals, or plants." Criteria to be considered in applying the definition included: "(a) the toxicity of the waste and its normal decomposition products after disposal in the environment; (b) the biological magnification of toxic components of (1) the wastes, or (2) the natural decomposition products of such wastes; and (c) the seriousness of the hazards in terms of the quantity and concentration of the waste disposed of and the likelihood of adverse effects occurring from the disposal of such wastes." [2:452–3]

Much discussion concerned the extent to which existing legislation was suitable for dealing with hazardous wastes and what kind of new legislation might be necessary. On the one hand, some witnesses held the view that new legislation should be "confined to the regulation of hazardous wastes which are not now subject to reasonable, effective and appropriate control under other existing Federal laws such as the Clean Air Act; Federal Water Pollution Control Act; and the Marine Protection, Research and Sanctuaries Act * * *. EPA should be required to issue regulations * * * identifying unsafe disposal practices and hazardous wastes and establishing control standards and State guidelines through formal rulemaking procedures." [2:453] Others, however, felt that "specific legislation directed to provide environmentally safe disposal of hazardous or other solid wastes is more appropriate than attempting to use the authorities of the Federal water Pollution Control Act and the Clean Air Act to accomplish this purpose." [2:463]

In general, however, there was agreement that, as expressed by one witness, "the Federal Government must take a leading role in setting standards for the treatment and disposal of hazardous waste. However, these Federal regulations should merely serve as minimum standards and should not prevent any State or locality from imposing more stringent requirements." [2:253]

—Summary by L. Harold Bullis.

Appendix: List of Witnesses

Part 1

Opening Statements

Domenici, Hon. Pete V., U.S. Senator from the State of New Mexico.
McClure, Hon. James A., U.S. Senator from the State of Idaho.
Randolph, Hon. Jennings, U.S. Senator from the State of West Virginia.
Stafford, Hon. Robert T., U.S. Senator from the State of Vermont.

Alphabetical List of Witnesses

TUESDAY, JUNE 11, 1974

Page, Dr. Talbot, and Dr. James W. Sawyer, Research Associates, quality of the environment program, Resources for the Future.
Sawyer, Dr. James, Jr., Research Associate, Resources for the Future, Inc.

WEDNESDAY, JUNE 12, 1974

Darnay, Arsen J., Deputy Assistant Administrator for Solid Waste Management Programs, Environmental Protection Agency, accompanied by John Lehman, Director, Hazardous Waste Management Division.

THURSDAY, JUNE 13, 1974

Parks, Hon. Lyman S., Mayor, Grand Rapids, Mich., appearing on behalf of the National League of Cities and the U.S. Conference of Mayors, accompanied by

Moore, Harry L., Director of Legislation, Glass Bottle Blowers Association.
Sheehan, John J., Legislative Director, United Steel Workers of America.

TUESDAY, JULY 16, 1974

Breier, John, Sensible Citizens Against Throwaways, Bethesda, Md. and Arthur Purcell, Center for Science in the Public Interest, Washington, D.C.
Lane, Leonard, Sierra Club.
Matthews, John, Oregon Environmental Council.
Purcell, Arthur H., Center for Science in the Public Interest.
Taylor, Ms. Pat. Environmental Action, Inc., Washington, D.C.

Part 3

WEDNESDAY, JULY 17, 1974

Cutler, Herschel, Executive Director, Institute of Scrap Iron & Steel, Inc., accompanied by: Thomas H. Boggs, Jr., Washington counsel to the institute; James Anderton, Simon Iron & Steel Corp., Lansing, Mich.; Louis Kaplan, H. S. Kaplan Scrap Iron & Metal Co., St. Paul, Minn., Joel Schiavone, Michael Schiavone Sons, Inc., New Haven, Conn.
Flood, Ted, Vice President Browning-Ferris Industries, Inc.
Gershowitz, Harold, President, Waste Management, Inc.
Hale, Samuel, Jr., Vice President, Marketing SCA Services, Inc.
Klaff, Jerome L., former Chairman, National Commission on Materials Policy, accompanied by: Boyd Outman, former consultant to the National Commission on Materials Policy and David Tillman, consultant to Mr. Klaff.
Lesher, Richard L., President, National Center for Resource Recovery, accompanied by Wade St. Clair, Director of Information.
Mighdoll, M. J., Executive Vice President, National Association of Recycling Industries, Inc. (NARI), accompanied by: Edward L. Merrigan, counsel, NARI.
Wingerter, Eugene J., Executive Director, National Solid Wastes Management Association, accompanied by: Ted Flood, Vice President, marketing, Browning-Ferris Industries, Inc., Houston, Tex.; Harold Gershowitz, President, Waste Management, Inc., Oak Brook, Ill.; Samuel Hale, Jr., Vice President, marketing, SCA Services, Inc., Boston Mass.

THURSDAY, JULY 18, 1974

Quaries, John R., Deputy Administrator, Environmental Protection Agency, accompanied by: Roger Strelow, Acting Assistant Administrator for Air and Waste Management.
Rampacek, Carl, Assistant Director, Metallurgy, Bureau of Mines, Department of the Interior.

XI. REQUIREMENTS FOR FULFILLING A NATIONAL MATERIALS POLICY

Summary of the Proceedings of an Engineering Foundation Conference (Henniker III) August 11–16, 1974 [1]

The third biennial "Henniker" Conference on national materials policy was devoted mainly to tutorial papers and workshop sessions on the following five subjects: information systems, the international flow of materials, materials conservation through engineering design, materials recycling, and the role of the technical societies—stressing the international aspects. The conference arrived at no formal conclusions or recommendations, but the workshop participants did arrive at consensus on a number of issues, although the workshop findings also reflected differences on some aspects of national policy.

* * * * * * *

INTRODUCTORY SESSIONS

Emilio Q. Daddario, Director of the Office of Technology Assessment, keynoted the conference. In referring to the importance that the Congress places on materials policy issues, he said that "the great majority of OTA initial assessment topics are tied together by the common thread of concern about the availability of natural resources and materials supplies," including assessments in the specific area of materials resources and the "vitally related areas of oceans technologies, world food supplies, and the overall energy picture."

Daddario noted the importance of both materials issues and conferences, like the "Henniker" conferences, to the Congress and stated that "Over the last year something like a hundred different bills have have been offered in Congress dealing with materials subjects."

John B. Wachtman, Jr., then president-elect of the Federation of Materials Societies (FMS), welcomed the conference participants on behalf of that organization in its role as organizer of the conference. Wachtman said that FMS had the "general goal of providing a national focus for materials activities of such broad character that cooperation between individual technical societies is required for most effective execution. The members of FMS are materials-oriented societies, not persons * * * [which] represent the broad materials interests of some half million materials scientists and engineers."

Richard W. Roberts, Director of the National Bureau of Standards, discussed materials research: a strategy to improve the performance of materials. He noted that the search for materials policy guidance officially began in 1930 when President Hoover established

[1] Henniker III: Requirements for fulfilling a national materials policy. Washington, Office of Technology Assessment, 1974.

the first commission on materials policy. Advances in materials technology since that time, "if anything, have increased the urgency of the quest for firm materials policy."

The first part of Roberts paper dealt with the materials cycle, or the cycle of materials use. Noting the claim of some economists that we have nothing to worry about in materials supply "if the price is right," Roberts felt that "materials conservation especially through the mechanism of improved performance, is the immediate, and probably the long-term answer to many of our shortage problems." He continued that although there may be an "initial economic penalty" for increasing the materials performance of products, over the long-term such actions will prove to be beneficial, because, among other things, the total life cycle cost will be lower.

Roberts stressed that improved materials performance was an imperative, both for increased international competitiveness with countries like Japan and those of Europe, and for achieving and maintaining a high national standard of living. He felt that increased materials R. & D. was the key to the solution of these materials problems and that the Nation has at least the following five technical options to use: development of new materials; development of new processing techniques; improvement in manufacturing and fabrication techniques; improvement in nondestructive evaluation techniques; and improvement in design theories and concepts.

He also believed that the use of these techniques to improve materials performance would rest largely with industry, with support from government, the universities, and technical societies.

The second part of Robert's paper dealt with the "need [for] a well-defined policy framework to guide the country in managing its material resources." Roberts felt that one of the clearest statements of materials policy had been set forth in the Mining and Minerals Policy Act of 1970 which implied that, for the most part, supply and demand would be left to the economic forces of the marketplace. Other policy elements, he continued, "are a collection of diffuse, uncorrelated, and often contradictory strategies which govern specific areas related to materials supply," consisting of executive orders, administrative rules, and statutory and common law.

Roberts felt that the most notable description of materials policy elements were to be found in the following acts of Congress:

> The Organic Act for the Geological Survey 1879, The Organic Act for the National Bureau of Standards 1901, The Organic Act for the Bureau of Mines 1910, Strategic and Critical Materials Stock Piling Act 1946, Defense Production Act 1950, Atomic Energy Act 1954, International Revenue Act 1954, Domestic Minerals Act 1953, Agriculture Trade Development Act 1954, Helium Act 1966, Mining and Mineral Policy Act 1970, Resource Recovery Act of 1970. (p. 15)

In discussing the types of materials policy, he continued that: "As you can see, the predominant impact areas of these policy elements are the development of resources and production capabilities. In other words, they cluster around the supply end of the materials spectrum. At the other end of the spectrum, the disposal end, we see a newly developing area of policy. With either end of the materials spectrum

pretty well covered or at least accounted for, we now face the no man's land of materials utilization and performance where policy has not yet made significant inroads." (p. 15)

Roberts concluded that the nation has a fair capability to formulate recommendations for a materials policy through the individual efforts of knowledgeable persons, trade associations, private industry and consumer groups but that what the nation lacked was "an authority in the government whose prime interest is in guiding the materials policy on a day-to-day basis." He further stated that although there have been numerous advisory groups and reports on materials policy, "until there is a well-defined organizational structure to take the recommendations of advisory groups * * * and fight for them through the legislative process, I can guarantee that no unified materials policy will ever be established or implemented."

Julius J. Harwood, Director of Physical Sciences of the Ford Motor Company, discussed the automobile industry's R. & D. response to materials shortages. Harwood listed the particular materials needs of the automobile industry and concluded that:

> While the overall resource availability picture for the next decade is reasonably encouraging, competition among nations for the World's raw materials and energy will be more intense than during any time in the past. We anticipate therefore, that material shortages will continue to be prevalent and mateials supply problems will be an ongoing way of life. All of this assuredly will mean higher materials cost. (p. 19)

Specifically in terms of automobile materials, the industry perceived that:

> During the remainder of this decade materials will be an irritating and periodically critical supply problem area. Materials shortages will be prevalent. Not only in some individual commodity areas will there be insufficent capacity to satisfy demand, but there will be unprecedented world wide intense competition for materials. Some projections for the steel industry indicate a 2–10 million ton shortfall between demand/supply by 1980. The United States share of available world resources will decrease. We anticipate as likely possibilities materials embargo pressures and threats, with perhaps no long term sustained impact, but certainly capable of causing local difficulties. (pp. 19 and 21)

Harwood discussed the industry efforts, particularly in R. & D. and design responses to materials shortages situations, which included the use of lower weight vehicles and substitutions of more prevalent for scarcer materials. He concluded that "R. & D. programs in substitution, conservation, reclamation and management of materials can provide responsive opportunities to offset some of [the] pressures and problems" of materials availability, supply, and costs.

Tutorial papers

The first day of the conference was devoted to five tutorial papers on the five major themes of the conference. After the introductory discussions, summarized above, **J. H. Westbrook** of the General Elec-

tric Company gave the first paper on materials information: an examination of the adequacy of existing systems. Westbrook stated that a very large amount of information about materials was needed and that the general state of materials information had caused "bewilderment, apprehension, dismay, frustration, and outrage" on the part of the users of this type of information. Because of the major problems existing in the state of materials information systems and the use thereof, the Office of Technology Assessment (OTA) had asked the Federation of Materials Societies (FMS) to conduct a quick but comprehensive survey of the breadth and intensity of the materials information problem. Westbrook's paper was an interim report of some of the survey's preliminary results. At the time of this paper, about 700 respondents had answered survey questions "as to the nature and importance of the attributes of certain information sources frequently used and highly valued by the respondent."

Less than 15 percent of the respondents found the present materials information situation satisfactory and more than one-third rated it highly critical. Two-thirds of the respondents thought that materials information users were not adequately informed or tied in with materials information generated and organized by foreign sources.

The most startling result of the survey, Westbrook said, was that the "668 responses to the questionnaire evoked the citation of 574 unique sources [of materials information] * * *. This great diversity of important sources is one of the root causes of the materials information problem."

Westbrook concluded that the preliminary survey produced the following useful insights into the problems of the management of materials information:

> 1. The critical importance of the materials information problem is recognized broadly.
> 2. Attention is required for improved evaluation, condensation, presentation and mechanization of materials information.
> 3. There are special problems with proprietary information, foreign information, and supply/demand statistics.
> 4. There are educational problems acquainting information specialists with the needs of materials people, teaching materials technologists the tools and techniques of information specialists and in presenting design engineers with materials information in a form they can understand and use. (p. 39)

John Morgan, Jr., Assistant Director of the Bureau of Mines, gave a tutorial paper on the current status of the U.S. mining industry and the need for both increased production and interest productivity. Principal indicators of the importance of materials to the national economy, referred to by Morgan, were that it annually needs over four billion tons of new mineral supplies each year (two decades ago the amount was only about half that much) and the value of domestically produced energy and processed materials of mineral origin exceeds $175 billion annually. On the negative side, the domestic production of both raw and processed minerals was not keeping pace with this demand. Morgan cited the Second Annual Report under the Mining and

Minerals Policy Act of 1970, by the Secretary of the Interior, in reference to nine major problem areas causing the domestic mineral production not to keep pace with domestic demand. These problems were confronting the mining, minerals, metal, mineral reclamation, and energy industries as follows:

> (1) Mineral imports have an unfavorable impact upon the U.S. balance of trade and upon the U.S. balance of payments;
> (2) Expropriations, confiscations, and forced modifications of agreements have severely modified the flow to the U.S. of some foreign mineral materials produced by U.S. firms operating abroad, and have made other materials more costly;
> (3) U.S. industry is encountering greater competition from foreign nations and supranational groups in developing new foreign mineral supplies and in assuring the long-term flow of minerals to the United States;
> (4) Development of the U.S. transportation net is not keeping pace with demand, thus seriously affecting the energy and minerals industries;
> (5) Removal of billions of tons of minerals annually from the earth contributes to a variety of disturbances;
> (6) The U.S. mining, minerals, metal, and minerals reclamation industries are encountering increasing difficulty in financing needed expansion of capacity and the introduction of new or improved technology;
> (7) Management of the resources of the public lands, including the continental shelves, must be improved;
> (8) The factual basis for the formulation and implementation of environmental regulations must be improved, so that man and nature are properly protected with minimum dislocation of important economic activities; and
> (9) The U.S. Government information base for the conduct of its mineral responsibilities is grossly inadequate. (pp. 43–44)

Morgan summarized (1) the basic problems with materials supply and (2) ways to conserve materials by recycling and substitution. The thrust of his tutorial was that the Nation faces major problems in materials demand and supply, but also possesses major advantages, like abundant mineral resources in a land area exceeded only by Russia and approximately equalled individually only by China, Brazil, Australia, and Canada. He believed that the best way for the Nation to cope with its future materials problems was—quoting a recommendation of the Final Report of the National Commission on Materials Policy:

> [T]o rely on market forces as a prime determinant of the mix of imports and domestic production in the field of materials but at the same time decrease and prevent wherever necessary a dangerous or costly dependence on imports. (p. 44)

Ira Grant Hedrick, of the Grumman Aerospace Corp., spoke on the designer and materials conservation. Grant said that perhaps the best summary statement of the relation of materials design to mate-

rials use was to be found in the report of the Federation of Materials Societies to the National Commission on Materials Policy, to wit:

> In the most general sense and in relation to materials use and conservation, it means that in a given application or product, our aims are:
>
> 1. To develop, select and design into products materials that most efficiently meet application requirements, that have optimum durability and life, and that are recyclable.
>
> 2. To process and fabricate materials so as to consume, waste or disperse the least amount of materials for equivalent performance. (pp. 53–54)

Taking these principles as given, Hedrick addressed the following two issues:

> 1. What must we do to provide the individual product designer with the tools, the training and motivation to implement this shift in design philosophy towards materials conservation?
>
> 2. As new materials and processes emerge from our research and development laboratories which might better serve materials conservation, what must we do to overcome the traditional reluctance to apply new materials and manufacturing techniques? (p. 54)

In addressing the first issue, shifting materials design philosophy towards greater materials conservation, Hedrick identified three "mechanisms" which could help promote more materials conservative design: shifting customer appeal; better assessment of the true value, rather than the dollar cost, of materials to our society; and applying artificial (non-dollar) constraints in favor of materials conservation. Hedrick recognized that to do this materials designers "must be equipped with new tools, training and motivation." For example, aerospace designers should be taught to use a "design-to-conserve" philosophy which would take the entire "life cycle" cost of a product into consideration during its design. To indicate the importance of such a philosophy, Hedrick gave as an example a modern fighter aircraft whose raw materials costs are only about five percent of the total finished product cost. However, "the materials choice made during design impacts elements responsible for an overwhelming 75% of the life cycle costs. The materials chosen affect the size of the aircraft and engines, what it will cost to produce it, how much fuel it will burn in its lifetime, what it will cost to maintain and repair it, and so on."

In addressing the second issue, accelerating the use of new materials and processes, Hedrick cited a 1971 report by the National Materials Advisory Board of the National Academy of Sciences-National Academy of Engineering which studied the factors which promote or inhibit the introduction of new materials in national programs. The report identified major causes of delay as:

> *Technical.*—including uncertainties in performance and reliability in service and the limited initial availability of design and fabrication data and product forms.
>
> *Economic.*—including the high initial costs of the material due to limited volume and the high capital facilities investment.

Management and organization.—including innate conservatism and the reluctance to assume the additional management task associated with the use of new materials.

Contractual.—including procurement specifications which limit the use of new materials and the unilateral risk which must be assumed by the contractor. (p. 63)

In conclusion, Hedrick said that a procedure for the accelerated selection, development, introduction, and use of promising new materials and processing techniques must be devised. He stated that "the proper execution of these tasks clearly requires the guidance and support of a dedicated national materials body which draws from all the necessary concerned groups from government, industry and the academic world."

Seymour L. Blum addressed the subject of materials and energy conservation through recycling in his tutorial paper. His approach was to discuss the conversion of municipal solid waste to energy in terms of a systems analysis to the solution of this problem. Blum believed that incremental growth in recycling, and resource and waste management in general, could be planned if the planning properly took into account all the factors involved, from the generation of waste to its utilization or destruction. Blum particularly emphasized the factors of technology, institutional concerns, and economics, and mentioned that human motivation also had to be taken into consideration. Using the recycling of municipal solid waste as an example, he introduced various diagrams, flow charts, graphs, tables of data, and lists of alternatives and options to show how the recycling issue can be dealt with systematically. While he did not arrive at a quantitative solution to the national or individual recycling problems, Blum showed that the area of materials and energy conservation through recycling was amenable to a rational approach which was, perhaps, a first step in large scale planning toward the solution of the problem on a national scale.

Nathan E. Promisel presented a tutorial paper on international problems and opportunities; a role for the technical societies and many others. Promisel stated that the field of materials was a dramatic example of U.S. international involvement, citing as an example the petroleum embargo of 1973. And yet, he continued, "with all these global materials problems, there is no established or recognized international organization whose major thesis, precept, or focus is founded on materials and processes. There is no such organization able to serve as a knowledgeable and adequate forum or mechanism for discussion, information exchange, mutual planning, international cooperation, integrated action, or even integrated response to materials problems and needs generated either nationally or in other international groups."

The reasons an international materials organization was needed were quite obvious, according to Promisel. These reasons included:

The current long-range problems of energy, materials, and the environment are global in scope and interdependency;

Multilateral materials and process technology transfer to the developing nations would be very beneficial to those countries;

Certain sectors of materials engineering, like exploitation of mineral resources in the seabed, require international cooperation;

There is a need for a good mechanism for the exchange of scientific and technical information and personnel and for cooperative programs;

Just as the United States is in the process of evolving a national materials policy, so are other countries. Similarly, it is useful to understand foreign organization and administration of materials science and engineering. "The last time this was done was in 1961 through the limited medium of a NATO symposium."

"There is a need for a mechanism to define important world problems to which materials science and engineering can make significant contributions for their solution and easement." (p. 80–81)

Promisel thought that there were a few existing organizations international enough in scope to fill the need he envisioned for such an organization. He said that the United Nations could conceivably serve this purpose, but he suspected "that it would be extremely cumbersome and complex to set up the desired organization within the U.N." His suggestion as the best approach "to forming a materials union of some kind is to build anew, building, in other words, our own umbrella, using existing international groups in other areas for guidance and assistance."

Promisel offered two suggestions for organizing an international materials organization. One approach might be to use the concept of the Federation of Materials Societies, expanded to a global basis. This would require enlisting selected materials and materials-oriented societies, wherever they exist internationally, to create a strong nucleus for further expansion. Another approach would be the "recurring suggestion over the past 15 years of an International Materials Year [which] would be another significant aid in launching an enduring international materials organization."

P. J. Fallon, of the British Embassy in Washington, D.C., spoke on the subject of materials policy in the United Kingdom. He stated that the U.K. position on raw materials was very different from that of the United States because the United Kingdom relied very heavily on imports of minerals for industry and energy.

Being heavily dependent upon imports of materials, Britain had more cause for concern about the materials supply and price issues than did the United States. Along with others, though, Fallon did not believe that cartel-type action would be extended to other raw materials to the same extent and with the same effect as OPEC had on the international petroleum supply in 1973. In regard to price levels of commodities, Fallon said that "the critical factor affecting commodity price trends is the level of demand in the industrialized consumer countries, and this is difficult to forecast."

Fallon stated that the United Kingdom was participating in the work of a number of international organizations concerned with raw materials, including various committees of the United Nations, the International Tin Council, the European Economic Community, and the Organization for Economic Cooperation and Development (OECD).

The British strategy to minimize future materials supply problems, according to Fallon, had been to:

> Commission a program to provide basic geological information on areas of potential mineralization;
> Provide financial assistance for exploration in the United Kingdom;
> Support R. & D. on minerals processing and metal extraction; and
> Create a regime in which commercial exploration may flourish, and at the same time promote the recovery and conservation of materials.

Because of its materials supply problems, the United Kingdom was particularly anxious to make the best use of its own sources of raw materials through recovery and reuse of materials when possible. Fallon stated that:

> The reclamation industry is one of our most valuable indigenous resources: 62 percent of the lead, 58 percent of the platinum, rather more than half of the steel, about 40 percent of the copper, paper and board, 26 percent of the aluminum and 21 percent of the zinc consumed in the United Kingdom are derived from reclaimed and recycled materials. (p. 87)

He continued that "recovery is closely bound up with methods of waste disposal [and the] problems of coordinating the wide range of organizations, materials and industries." He also noted that "there are considerable problems of markets, economics and technology to be overcome if significant increases in recycling are to be achieved." (This last statement was reminiscent of Blum's emphasis on technology, institutions, and economics as major components of the systems analysis approach to resource recovery and materials conservation.)

The third major approach to solving some of the British materials problems commented on by Fallon involved materials substitution, design, and conservation. Many ways to improve materials conservation through substitution and design were noted by Fallon, but practical problems arise, for example, in knowing when in the production process to substitute one material for another, and how to deal with the response of society in developed countries to the introduction of improvements. Fallon mentioned as an example of the latter point that:

> Although more positive attitudes are developing on the recovery and recycling of waste, the "man in the street" is probably reluctant to accept extended product life (or reduced lifetime cost) if this entails an increased initial outlay; but this attitude may change with time. (p. 89)

D. W. Ballard reported on the U.K. Conference on Conservation of Materials held in March 1974. He summarized his observations in the following way:

> 1. Our potential materials shortages in the USA are significantly less than the outlook for the UK. A program for internal self-sufficiency in energy fuels as President Nixon initiated in the USA would be impossible in the UK. The

same comment would be applicable to many of the other critical industrial materials.

2. A conservation ethic has been in effect in the UK of necessity for a number of years. Nevertheless, all persons agreed that what they have been doing in the recycling and more efficient materials utilization must be intensified as soon as possible. It was quite apparent that they considered our "throw-away" habits and "cosmetic obsolescence" practices in the USA as a major burden on the rest of the industrialized world as well as the emerging nations.

3. A strong concern and anxiety was expressed as to the possibilities of "materials blackmail" practices by the nations with major raw materials sources. It was evident that the success of the Arab "oil blackmail" had triggered this concern.

4. During the final session, recommendations were made that the United Kingdom make a materials policy study similar to our NCMP one, using much of the NCMP recommendations as deemed applicable to the UK. The wrap-up speaker, Dr. J. Pick of the University of Aston, felt a strong message to Her Majesty's Government should be sent from the Conference pointing out the urgency of maximizing materials conservation practices.

5. Follow-up conferences on various aspects of this subject are planned. These will probably be directed towards specific materials and/or industries in the UK. (p. 92)

C. M. Cosman, then consultant to the United Nations, presented a pessimistic picture of the international situation caused by the crisis in raw materials brought on by the recent Arab oil boycott. He pointed out that the crisis had endangered the patterns of commerce which had served the entire world during the last 25 years. He concluded that "before decisions are made that set the world irreversibly on the course of economic nationalism, the nations should give pause and get together and evaluate these trends, and see whether there is no possibility of composing these differences.

TASK FORCE REPORTS

Following the tutorial papers on the five theme subjects for this "Henniker" Conference, the attendees organized into five task forces to consider the five subject areas. Each task force dealt with two areas and wrote a report on each subject. This section summarizes those reports.

Management of materials information

The first task groups dealt with the following issue: what can be done to improve the availability of pertinent, timely, reliable, and adequate information in all aspects of the materials life cycle to those who need this information in the conduct of materials programs, projects, application, and policy formulation? The two task forces that dealt with this issue agreed that (1) most elements of a materials information system already exist within the government and (2) public and government interest and participation in the collection and

dissemination of materials information should be encouraged. One of the task forces held that no major new bureaucracy was needed in the materials information field, but that there should be a central coordinating agency to oversee the collection of data within existing agencies. The other task force disagreed on this point and held that a new Cabinet-level department should be established to take charge of materials information. One task force said that a survey is needed to determine what kinds of data are already available and that the survey could be done through existing agencies. On this same point, the other task force held that information on mineral resources should be collected by individual agencies and coordinated by the new Cabinet-level department and that the new department should also be responsible for information on the production, consumption, and reuse of materials.

The increasingly international character of materials issues

The issue to be dealt with by the second set of task forces was: what is the scope of materials issues shared in common by the nations of the world for which there exists or could develop a broad motivation for cooperative efforts at solution? The two task forces that dealt with this issue agreed that (1) the Nation should maintain materials stockpiles for economic purposes, (2) materials self-sufficiency is not a reasonable national goal, (3) materials science and technology are important aspects of furthering international cooperation; specifically the United States should export its materials science and technology in exchange for raw materials from less developed countries and for other technologies from more advanced nations, (4) there is a need for better interaction, communication, and trade between nations, particularly with Communist China and Russia, which can be handled through existing organizations, (5) no new Federal agencies are needed to better this international communication, although closer ties are needed between government and multinational corporations, the latter of which could be important in encouraging international cooperation and communication, and (6) a wider (international) materials information base is needed.

The two task forces in this subject area disagreed on a point similar to that of the first task groups, that is, one task force said that no new bureaucracies were needed to foster the national aspects of materials issues while the other task force said that a Department of Natural Resources should be created along with an independent agency for data collection along the lines of the National Commission on Supplies and Shortages.

The task forces agreed that one of the best ways to foster international cooperation would be to set standards for, and exchange, technical information. One task force emphasized that some institutional factors inhibit international cooperation, only some of which can be eliminated by governmental actions.

Design improvements to increase efficient utilization of materials

The issue that the third set of task forces dealt with was: what design improvements will improve efficiency of use of materials and energy? Both task forces were largely in agreement and reported that (1) there are many barriers to optimum materials use, including barbiers to the introduction of new technologies, (2) economic constraints to the increased efficient use of materials are perhaps the most impor-

tant constraint, but institutional factors are also important, especially in the encouragement of innovation, but can be dealt with by the Federal Government, (3) a vigorous government program is needed to educate the public on materials options. like the encouragement of materials conservation. (4) there is a need to find new ways of improving the quality of products in terms of lifetime and recyclability and to disseminate information on this subject. (5) there is a need to improve durability and find areas where substitutions for materials can be made. (6) government design and performance specifications to promote materials conservation should be investigated, (7) areas of direct government intervention which affect materials conservation practices, like standards setting, should also be investigated, and (8) serious materials supply and shortage problems are ten to 15 or more years in the future, but it is necessary to begin examining government policy alternatives now before it is too late.

The two task forces dealing with this topic also commented that there are many constraints to innovations in designing materials for improved use and there is a corresponding need for government incentives for innovation and a need for more effective government-industry cooperation. An example of the last point was the suggestion that the government could define the material and energy content of products in order to educate the public in regard to materials and energy conservation. The government could also revamp its purchasing system to encourage efficient materials use.

Mobilizing economics and technology for materials recycling

The issue defined for the fourth set of task forces was: what actions, public and private, could motivate the more complete recovery of waste and greater utilization of secondary materials, thus closing the materials cycle? The two task forces agreed that there was a combination of institutional constraints and weak economic incentives which currently inhibit recycling efforts. This situation should be reversed and government should enhance the marketability of recycled materials, promote voluntary industrial programs for purchasing and disposing of materials, and encourage government-industry R. & D. and recycling efforts.

One of the task forces commented that there had been no incentives to promote the recycling of materials from the municipal waste streams and that waste should be reduced by promoting product durability, repairability, and maintainability. The other task force commented that Federal and State governments should share the costs of developing recycling technologies; there are many recycling technologies, but no single optimum process can be found for use in all locations; the cost of water used in materials processing—including the cost of restoring it to recyclable quality—is often overlooked; landfill requirements and regulation should be reexamined; and products should have their social as well as economic costs listed, including disposal costs and materials and energy requirements.

The role of the technical community in national and international management of materials

The issue for the fifth set of task forces was: can members of materials groups, such as materials societies formed for various public, corporate, and informational purposes of persons in technical dis-

ciplines, organize cooperatively for larger national and international objectives and programs related to the combination of disciplines they encompass? The two task forces agreed that (1) there are certain goals compatible with the objectives of all countries which could be discussed cooperatively by technical communities in most nations, like improving the international situation to the point where the exchange of materials, goods, and services takes place with minimum dislocations, (2) technical societies can assist in the exchange of technology and the identification of problems and opportunities which warrant legislative action, and (3) at present there is not a need for an international federation of materials societies, since this type of exchange already exists.

The two task forces commented that technical communities, including professional societies, should assist in educating the public about more efficient use of materials and should focus their attention on materials information in many areas and the need to strengthen educational weaknesses in the materials science field. They also noted that there was a need for greater cooperation between industry and government in achieving materials policy objectives through international exchanges.

FINAL PAPERS

The final morning of the conference was devoted to the presentations of three papers.

F. H. Buttner, of Battelle, Columbus Laboratories, addressed the conference on stockpiling for the future. Buttner said that the stockpiling of materials for economic purposes was just one of four major actions which a nation could use to combat materials scarcities, the other three were to maintain industrial standby capacity and to promote materials substitution and materials recycling. In discussing these four options, Buttner said that the major disadvantages of stockpiling were "its high capital cost * * *, its continuous management cost, its long lead times to build, and its potential disruptiveness in the marketplace. But, I hasten to add to the last that a properly managed stockpile need not necessarily be disruptive."

Buttner commented further that the major advantages of maintaining industrial standby capacity were that it could provide a quick reaction capability to scarcity problems or a relatively short lead time to put it to use. Its major disadvantages were high capital tie-up, rapid depreciation of capital through obsolescense and deterioration of the plant standing in idleness. In addition, this option was usually disruptive to industry and usually required special government bodies to manage it equitably.

Buttner said that the option of materials substitution relieved critical material demand and in the long run could pay for itself. "Its major disadvantages is that substitution cannot take the economy far enough to combat broad and deep scarcity situations. Substitution technology is just not that well developed. To take the time to develop it will require long lead time."

The main advantage that Buttner saw in recycling was that it, "in effect, renews nonrenewable resources." However, he noted that its disadvantages, "just as with substitution, are that the technology is

yet to be developed to an extent required to consider it a therapeutic answer to scarcity. It will require long lead times to develop it fully * * *."

Buttner's thesis was that a proper and rationalized approach to the scarcity problem using a combination of all of the options he discussed would be a more sound approach to alleviating scarcities than relying exclusively or mainly on only one of the alternative approaches. He referred to the tutorial presentation of Blum in which Blum discussed a systems approach to recycling which emphasized the system interrelationships of technology, institutions, and economic factors. Buttner's approach was to model the scarcity problem in terms of stockpiling, standby capacity, substitution, and recycling to determine what would be the proper combination of these four options under given situations.

From his analysis, Buttner concluded that "the strongest strategy at this point in time is to go with stockpile long enough to buy time for Research and Development on Substitution and Recycling; then move away from stockpiling as the latter alternatives take hold with time. [Therefore] (1) Stockpile, as one of four inseparable tools to remedy scarcity, is a keystone in a rational plan for the future. (2) To turn away from stockpile is to deny ourselves of a crucial tactical option in dealing with scarcity."

In order to reduce the cost of the stockpile option, Buttner suggested (1) eliminating the stockpile entirely, which is unreasonable (2) transferring the stockpiling responsibility entirely to industry by providing industry with incentives to bring their normal industrial buffer stocks of materials up to national stockpile levels (an option now gaining renewed attention), and (3) turning the stockpile into a commodity reserve currency under which materials could back up paper money in the same way gold had historically.

Buttner also discussed materials stockpiles as either domestic or international "buffer stocks" to be used to obtain supply continuity, price stability, and realistic price levels. "Japan recently set aside $800 million for acquisition of materials deemed scarce in the Japanese economy" to protect its trading interests.

Because national buffer stocks of materials for economic purposes may work at cross purposes at the international level if a number of countries develop them, Buttner suggested that a comprehensive international buffer stock program would be more beneficial. "It has the advantage of becoming a vehicle for international cooperation between consuming nations, and between blocks of consuming and producing nations." An international buffer stock would have the advantages, according to Buttner, of (1) relieving difficult materials procurement by the consuming countries during time of materials shortages, (2) relieving difficulties in selling materials by the producing countries during times of depressed materials demand and prices, and (3) of stabilizing prices for materials over longer periods than is now the case.

Yngve Vesterlund, of the Swedish Embassy in Washington, D.C., dealt with the current inequalities in the distribution of the world's wealth and use of materials. He said that the view of the Swedish government was that "for many important commodities, international agreements are the best means to achieve stable markets and provide

the producing developing countries with increased export earnings which are essential for their development."

Victor Radcliffe, of the National Science Foundation, addressed the issue: Materials, the next crisis? Radcliffe reviewed most of the concerns addressed throughout the conference and referred to the warnings of the Paley Commission [2] and the book "The Limits to Growth." [3] and addressed himself to the basic question, is materials really the next world crisis? His answer for the short term was that "materials is not the next crisis for the United States or indeed, the world at large. Undoubtedly, there will be price changes, supply perturbations and alterations in industry structure, but in economic terms none of these developments appear likely to result in a crisis situation, i.e., one comparable to the world energy crisis of the recent past and the world food crisis that appears possible in the near-term future."

As to the long-term issues, that is, the ones of the world of the year 2000 and beyond, Radcliffe stated that:

> At the present time, there is increasing recognition that market forces alone may not move the United States and other developed countries rapidly enough towards ensuring that these science and technology activities develop timely contributions to the solution of meeting needs for materials in the future. (p. 164)

However, taking all the factors into consideration, that is, those factors discussed throughout the conference and the materials establishment generally, Radcliffe concluded that:

> while the reasons differ from those for the short-run case considered earlier, the longer term likewise does not threaten a materials "crisis". In particular, it is improbable that the world will "run out of materials" before other potentially critically issues intervene. However, the conclusion that no real crisis is likely for materials does not mean that, in the absence of appropriate attention, serious problems may not arise in their supply and use. Public choices in both developed and developing countries will have to be made between the costs and benefits involved, especially over the immediate future when expanding new production will continue to be the principal means of meeting consumption requirements. (pp. 164–165)

—Summary by William C. Boesman.

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[2] The President's Materials Policy Commission, final report "Resources for Freedom", June 1952.

[3] Meadows, Donella H. et al. The limits to growth : a report for the Club of Rome's Project on the Predicament of Mankind. New York, Universe Books, 1974. 205 p.

XII. MATERIALS AND MAN'S NEEDS

Summary of the Report of the Committee on the Survey of Materials Science and Engineering (COSMAT) 1974 [1]

The COSMAT report was based on a survey of over 1,000 practitioners in the field of materials science and engineering (MSE). The National Academy of Sciences (of which COSMAT was a committee) commissioned the survey to investigate the field of MSE which has emerged as a recognizable activity in its own right over only the past two decades, and to determine how MSE fits in with the broader field of materials as a whole. The basic report was accompanied by four additional detailed reports on the history and scope, needs and opportunities, and institutional and international aspects of MSE. The report included 24 recommendations and emphasized the need for Federal leadership, in a system analysis mode, for the entire interdisciplinary field of materials, including materials science and engineering, in light of the fundamental nature of the materials cycle and the materials-energy-environment triad.

* * * * * * *

The COSMAT report dealt with materials science and engineering (MSE), an important subset of the larger discipline or activity of materials and materials policy. The report covered a survey of over 1,000 persons and institutions. More than 100 specialists in the field of materials participated directly in the COSMAT program.

The report defined MSE as a multidisciplinary activity that was emerging as a recognizable activity in its own right, and which had done so only during the past two decades, or since the Paley Commission report. Moreover, as emphasized in the report, materials and MSE exist in a social and economic context that has changed markedly over the years 1969 through 1973, the five years preceding the report.

In addition to the COSMAT Summary Report discussed here, four other reports were also prepared by COSMAT. They are: (1) history, scope, and nature of MSE, (2) needs, priorities, and opportunities for materials research, (3) the institutional framework for MSE, and (4) aspects of materials technology abroad.

The overall objectives of the survey were stated to have been:

> To determine the nature and scope of materials science and engineering; to ascertain the linkage of science with engineering in the field of materials for the successful translation of new basic knowledge into useful application; to examine the interaction of materials science and engineering with other areas of science and technology; to discern trends in the development of the materials field in order to identify its chal-

[1] Committee on the Survey of Materials Science and Engineering (COSMAT). Materials and man needs: materials science and engineering. Washington, National Academy of Sciences, 1974. 217 p.

> lenges, opportunities, and needs; and to reach conclusions concerning the means by which materials science and engineering might contribute more broadly to the national well-being. (Page X.)

For purposes of the COSMAT report, certain substances, like food, drugs, water, and fossil fuels, were not included in the term "materials."

The report stressed the importance of materials to the national economy by stating that:

> By one of several possible reckonings, production and forming of materials account for some 20 percent of the Nation's gross national product, but the number is deceptive; without materials, we would have no gross national product. (pp. 2–3)

The report further stressed that the Federal Government had not yet developed a comprehensive materials policy. The report attributed growing weaknesses in U.S. materials science and engineering in part to the diffusion of responsibility for materials plans and programs at the Federal level.

Important concepts related to materials science and engineering, and the larger field of materials and materials policy, that were reiterated throughout the report were that:

> Materials should be dealt with systematically (that is, by systems analysis methods) as part of an overall materials cycle—from their extraction from the earth; through processing, design, and manufacture; use; and reuse or disposal back into the earth.
>
> Materials are only part of the basic triad of materials-energy-environment which should be treated as a whole in dealing with man's relationship to natural resources and effective national materials policy.
>
> Materials science and engineering is an evolving activity which is both multidisciplinary and interdisciplinary. An awareness of this nature of MSE is important since academia tends to organize and support research along disciplinary lines.
>
> Federal leadership is required for effective materials science and engineering and materials policy.

The report dealt at length with specific problems in the field of MSE that are strongly coupled to the Nation's success in satisfying its long-term needs, like problems in materials exploration, mining, extraction, substitution, the use of renewable resources, processing and manufacturing, environmental effects, product design, recovery and recycling; and specific materials needs in communications, space, electric energy, superconductors, high-temperature turbines, magnetohydrodynamic generators, breeder reactors, solar energy, energy storage, automobiles, mass transit, aircraft, health services, and other areas. The report also discussed specific areas of materials science and engineering research that need to be addressed in the national interest, like corrosion research, flammability of polymers, biomaterials, materials fracture mechanisms and defects, superconductivity, composite materials,

superalloys, ceramics, materials processing and testing, and materials research on fundamental properties of substances.

The report briefly noted materials problems related to the U.S. trade balance, including critical materials supplies; the recent trends in the Federal and private funding of basic and applied research; MSE manpower needs; the shifting Federal emphasis from defense, space, and atomic energy to the environment, other forms of energy, and quality; and so on.

RECOMMENDATIONS

The COSMAT report presented the following 24 recommendations (with specific agencies or other bodies sometimes suggested for implementation):

Materials policy as it relates to energy and the environment

The interdisciplinary capabilities of materials science and engineering should be systematically brought to bear on problems of environmental quality, with emphasis on the materials cycle and the materials-energy-environment triad.

The Federal Government should develop a broad materials policy in the context of the materials cycle and on the same level as related policies for energy and the environment, through the use of, among other methods, analytical and advisory capabilities.

Support of materials science and engineering

Critical materials research and development should be given high emphasis in national programs to alleviate energy shortages.

Materials research and development should be recognized as vital to achieving specific goal-oriented technical purposes and should be adequately supported, including special attention to the development of substitutes of more abundant materials.

Important opportunities for applied materials research of broad, generic types should be tackled more vigorously.

The allocation of Federal funds between basic and applied materials research of broad generic types should be continually examined and kept appropriate to national needs, in line with the preceding recommendation.

Fundamental research in materials should include relatively simple solids as well as more complex materials.

The opportunities for materials research afforded by Federal facilities and personnel should be used to the full.

Interdisciplinary materials research laboratories should continue to receive a substantial proportion of their support as block funds and continue to evolve techniques for effective local management of these funds.

Materials research and industry

Industry should work to integrate materials science and engineering with product design and manufacture.

Cooperation between industries in materials research and development should be expedited with active participation from Federal agencies like the Department of Justice and the National Science Foundation.

Mature industries in the materials field should strengthen their research, particularly in materials processing and manufacturing.

Materials research and academia

Universities should intensify their efforts to build interdisciplinary activities in research and education. (MSE is one of several logical vehicles for such an effort.)

Solid-state topics should play a more significant part in the undergraduate education of physical scientists, as well as of engineers.

Undergraduate curricula in materials should be designed to strengthen the role of engineering.

Materials research and other organizations

The National Research Council of the National Academy of Sciences-National Academy of Engineering should work toward taking full advantage of its opportunities to draw on expertise in the materials community.

Professional societies in the materials field should deliberately seek to coordinate their activities as, for example, through the Federation of Materials Societies.

Materials research coordination and materials information

There should be effective coordination of materials research programs among Federal agencies and departments.

Industry, government, and universities should cooperate in establishing needed regional and national materials research centers.

Government, industry, and universities should develop arrangements for personnel interchanges and interactions, and make the fullest possible use of existing ones.

Improved data- and statistics-gathering mechanisms useful for the multidisciplinary field of materials science and engineering should be developed and supported on a continuing basis.

Renewable materials and recycling

The feasibility of using forests and other renewable organic sources as raw materials for plastics should be assessed.

Resources of materials science and engineering should be invoked to increase the recyclability of materials and products.

International aspects of materials research

Urgent attention should be given to developing international cooperation in the materials field.

In summary, the report made specific recommendations derived from a survey of practitioners of MSE and from the direct participation of over 100 materials specialists. The recommendations stated what should be done in several areas of materials science and engineering and, often, by which groups or organizations. More importantly, perhaps, the report emphasized the need for Federal leadership, in a systems analysis mode, for the entire interdisciplinary field of materials, including materials science and engineering, in light of the fundamental nature of the materials cycle and the materials-energy-environment triad.

—Summary by William C. Boesman.

XIII. MEETING AMERICA'S RESOURCE NEEDS: PROBLEMS AND POLICIES

Summary of a Report by the Ad Hoc Committee on the Domestic and International Monetary Effect of Energy and Other Natural Resource Pricing to the House Committee on Banking and Currency November, 1974 [1]

This study, "Meeting America's Resource Needs: Problems and Policies" was undertaken to examine the current and projected status of mineral pricing import dependency and resource availability, domestic productive capacity and demand, and governmental activity or inactivity. This report was the second of several reports submitted by the Ad Hoc Committee on the Domestic and International Monetary Effect of Energy and Other Natural Resource Pricing to the House Committee on Banking and Currency. The study's overview conclusion was that our materials system is currently so plagued with problems that unless appropriate policy actions are taken within the near future, the system will undergo a basic transformation from a position of relative abundance (of resources) to a position of relative scarcity between now and the year 2000.

* * * * * * *

November 1974, the issue date of the report, was a period during which formidable energy, materials, and natural resource issues were the focus of much attention. Many of the Nation's resource-related problems were becoming more evident, as they increasingly touched personal lives, the functioning of industries, and the general state of the economy. Serious recognition of the energy/materials/minerals "problems of the day" was imperative.

Recognizing this, the Ad Hoc Committee pursued a problematic orientation in its study. Their approach was to examine the current and projected status of mineral demand, supply, price, import dependency, and government programs, paying particular attention to the existing and potential problems within these areas. The identified problems were then compiled, general objectives were determined, and specific policies (or recommendations) were presented to meet the objectives and solve the problems.

The Ad Hoc panel accepted the working premise that the minerals system must be viewed systematically. By discussing the system in this manner, the Ad Hoc Committee focused on the interrelationship between all natural resources and the subsequent need to establish policies that cover the entire minerals system, not just individual minerals.

With this assumption clearly stated, the study was divided into seven major areas: The Role of Demand; The Role of Supply; Price:

[1] U.S. Congress. House. Committee on Banking and Currency. Ad Hoc Committee on the Domestic and International Monetary Effect of Energy and Other Natural Resources Pricing. Meeting America's Resource Needs: Problems and Policies. Committee Print, 93d Congress, 2d session. Washington, U.S. Government Printing Office, 1974. 147 p.

Determinants and Effects; Import Dependency and Cartel Possibilities; The Nature of the Industry: Competitive Position and Capital Structure; The Role of Government in the Formulation and Implementation of Natural Resource Policy; and Policy: Problems, Objectives, and Recommendations.

Selected themes and conclusions from each of these sections are summarized below.

The Role of Demand

The first area discussed by the Ad Hoc Committee was the demand situation for minerals. To provide an understanding of the United States domestic demand and, in turn, survey the United States economic state, the Committee chose to examine current levels of minerals demand, factors that influence those levels, and future levels of demand.

They noted that 40,000 pounds of new mineral materials are demanded annually by each U.S. citizen and that over half of this demand is for nonfuel minerals. U.S. domestic demand for these nonfuel minerals can be influenced, according to the report, by such factors as population increase, increase in Gross National Product, environmental quality, rate of substitution, end use, intensity of use ratio, international market, pricing, and technology.

The Committee recognized that U.S. demand for minerals is a dynamic variable which, for the last 20 years, has been sporadically increasing. Furthermore, the study noted that even faster rates of increase are occurring in the rest of the world. It was concluded that increases of the demand for minerals will continue for at least the rest of the century. The report contained the important warning that Third World demand, which is increasing at a faster rate than United States demand, may push competition for available supplies to a potentially dangerous level.

To aid on the demand side, the Committee saw the need for several market adjustments and policy actions. Its suggestions encompassed: economic growth policies that include environmental programs, more technology for substitution and to improve end uses, international recognition of the need for cooperation within the nonfuel mineral market, and research and planning to establish a greater understanding of the interrelationships between nonfuel minerals.

The Role of Supply

The Committee next examined the current levels of domestic supply, the factors influencing these levels, and some supply projections. The report stated that although the current level of U.S. domestic supply is higher than the 1950 level, supply levels have not kept pace with demand levels. In fact, since 1950 the gap between domestic supply and domestic demand has been everwidening. Limited domestic mine production and a declining rate of refined metal production (in relation to the rest of the world) were the main causes cited for this situation. According to the study, other factors which bear on the level of supply were: the extent of U.S. reserves and resources, economic policy, technology, environmental quality, the international market, and the nature of the domestic mining and metal processing industry.

The Committee stressed that if the United States desires to avoid entering a position of mineral scarcity, it is time to recognize and react

to the increasing gap between domestic production and domestic demand; to the declining level of increase in domestic refined production; to the decreasing grades of ore; to the need for improved recycling of old scrap; and to the problems that hamper domestic mining and processing industries. Also, attention must be directed to increasing discovery costs and declining levels of exploration and to the current institutional disincentives for technological innovation. Thus, the Committee concluded that if shortages are to be avoided, technology must be fostered, recycling expanded, international cooperations established, and the shape of the mining and processing industry improved.

Price: Determinants and Effects

The study indicated that recent resource price increases have taken place in a climate of inflation which could be attributed to the combined factors of cyclical influences, excessively expansionary world monetary and fiscal policies, buoyant demand coupled with shortages in supply, and the cumulative effect of inflation on business and consumer expectations.

As previously noted, the Committee predicted that the steady long-term upward trend in minerals demand will continue. Supply will also continue to increase, although probably at a lesser rate. Therefore, according to the report, upward price adjustment to equilibrate the market would be required.

The Committee suggested that future movements in relative resource costs will be determined by the net effect of two trends. First, the tendency over time will be for utilization of increasing diffuse (or lower grade) resources, resulting in greater inputs of labor, capital, and energy. Second, the process of technological advance and the increased incentive for discovery of new reserves, which would be provided by the prospects of higher prices, would work to increase availability and to inhibit the rate of growth in production costs.

Also, the Committee brought out the fact that certain price projections did indicate a long-term upward trend in price movements for the remainder of the century. It was suggested that measures will be required to promote the technological innovation and capital formation necessary to moderate these projected increases. (See section at end of report dealing with recommendations.)

Import Dependency and Cartel Possibilities

At the time of publication of the report, there was concern over the possibility of cartel action (similar to that which had recently been imposed during the oil crisis by OPEC), by foreign producers over certain essential raw materials other than oil. Even though the prospects for future international mineral cartels were deemed slim, the Committee maintained that policy makers must not dismiss the possibility entirely. It was recommended that to offset the effectiveness of a mineral cartel, the United States could seek alternative foreign sources of supply, switch to substitute materials, and—with proper economic incentives—explore and develop secondary domestic deposits.

The Nature of the Industry: Competitive Position and Capital Structure

The Committee recognized that the domestic metals and mining industries are major components of our materials system. These indus-

tries influence the level of domestic materials production and contribute essential metals and ores to other industries.

Mining, smelting, fabricating, refining, and marketing are among the several operations of these industries. Many of these operations are characterized by a high level of concentration, vertical integration within the larger firms, and enormous capital requirements.

The Committee noted that severe capital flow problems were inhibiting the expansion of the industry. According to the report, these industries were plagued by increasing debt-equity ratios, lagging stock sales, increasing costs of borrowing, and increased competition for capital.

The Role of Government in the Formulation and Implementation of Natural Resource Policy

Any analysis of the United States materials system must include a review of the role of government in the formulation and implementation of natural resource policy. The Committee noted that government participation would be possible at various levels of the production process, including research, exploration and development, extraction and processing, and the recycling of resources and finished products. They suggested that a mix of policy tools can be used, including fiscal policy, anti-trust legislation, patent policy, aid to research and development, land-use and mining procedures laws, and import-export trade policies.

The report implied that the management of materials in the Federal Government leaves much to be desired. The problem of scattered and overlapping jurisdictions was considered to be of prime importance both in the Executive and Legislative branches. The Committee maintained that coordination and communication were lacking, thereby increasing the complexity of decisionmaking. Specific problems cited in the report included:

Interaction of fragmented jurisdictions has increased the complexity of policy formulation;

Independence and lack of communication has led to concurrent and often redundant policy actions by different agencies to cope with the same problem;

Decentralized decisionmaking has prevented a comprehensive, unified approach to the interrelationships between natural resources, energy, and the environment; and

Decisionmaking within individual agencies has been hampered by deficiences in the information-gathering processes.

Policy: Problems, Objectives, and Recommendations

The most outstanding problems identified in the study were as follows:

The World demand for natural resources is increasing at a faster rate than United States demand.

Increased demand for natural resources has led to environmental decay and degradation.

The market system has been deficient in its encouragement of the necessary research and development to continue the advance of technology.

Certain influences on the market system encourages convenience and waste rather than efficiency and economy in the end uses of resources.

The use of recycling programs to decrease waste and increase available supplies has been inadequate.

The market allocation system has proven to be rather inefficient in the short term, and sometimes into the middle term.

An expanding gap has developed between domestic production and domestic demand for natural resources, leading to an increase in dependency on import sources.

Production costs for natural resource development have shown a long-term upward trend as the grades of ore have declined and the prices of labor, capital, energy, and transportation have increased. Additionally, the rate of exploration has declined over the last few years.

The natural resource industry is highly capital intensive and the victim of serious capital flow problems including: changing debt-equity ratios, lower liquidity, difficulties in financing expansion through stock sales, increasing capital costs, and increasing competition for capital.

The scope of U.S. trading policy is shortsighted and has shown a limited ability to deal with threats to direct investments abroad and uncertainty of access to foreign resource markets.

U.S. mining laws are archaic, vague, and a source of uncertainty.

Scattered and overlapping jurisdictions occur in those areas of the executive and legislative branches charged with oversight of natural resources.

Drawing upon their analysis, the Committee discerned various policy objectives and specific policies to deal with these problems. Their objectives and policies are summarized as follows:

Objective one—Foster Increased Resource Availability From Domestic Sources

The Committee stated that a secure domestic supply of nonfuel natural resources is essential if we are to forestall supply disruption and vulnerability to price fluctuations. To insure adequate supplies, the Committee argued it was necessary to alter the tax structure, increase resource recovery, improve transportation, revise and consolidate U.S. mining laws, remove uncertainty with regard to government environmental policy, alter-consumer incentives, and create a public-private economic stockpile corporation.

Objective Two—Insure Sufficient Access to Foreign Supplies

The Committee maintained that as U.S. demand for materials increases between now and the year 2000, the United States should insure the availability of resources from low cost sources. To accomplish this end, a comprehensive set of foreign economic and political policies was recommended. The Committee suggested that emphasis should be placed on the interdependence of nations and the need for sources to meet all of the world demand. Participation in the United Nations Resource Committee was urged, as well as encouragement of

U.N. assistance and development programs to give prime consideration to developing countries in the development of their reserves. Also, modification of U.S. tax laws to take into account changing modes of investment was promoted. Furthermore, the Committee recommended multilateral negotiations to establish international investment and commodity arrangements and also bilateral agreements within the framework of multilateral arrangements.

Objective Three—Internalize Environmental Costs to Prevent Environmental Degradation

The Committee recognized that questions of the materials supply and environmental quality cannot be separated. To insure that United States domestic supply is fostered without destroying environmental quality, it was suggested that efforts be made to:

Establish the true extent and source of environmental damage associated with surface mining, materials processing, use, and disposition;

Improve the quality of the domestic environment by such actions as adopting a national program of land use planning, establishing an emissions tax, and revising Federal policy toward effluent standards; and

Improve the quality of the international environment by helping to establish international standards for materials policy and environmental quality.

Objective Four—Foster Research and Development and Technological Innovation

The Committee acknowledged that an important element of materials policy is research and development and technological innovation. The Committee suggested that we should enhance the coordination of materials R. & D., expand materials R. & D. efforts, and improve existing technology.

Objective Five—Achieve a Comprehensive Governmental Approach to Natural Resource Policy

The Committee recommended:

Improvement of the collection and treatment of information used to monitor natural reserve market developments;

Creation of an executive agency to oversee the natural resources area;

Formation of a non-legislative joint committee to respond to the Annual Natural Resource Plan of the President; and

Expanded use of the United States Geological Survey and the United States Bureau of Mines.

—Summary by Paul F. Rothberg.

XIV. GLOBAL COMMODITY SCARCITIES IN AN INTERDEPENDENT WORLD

Summary of a Report of the House Committee on Foreign Affairs, 93d Congress, 2d Session, December 23, 1974 [1]

This was a report of the House Committee on Foreign Affairs on hearings on the subject of "global scarcities". The report dealt with global scarcities of energy, minerals, and food which had occurred in the 1970s. The report stated that no other mineral can affect the U.S. economy like oil. In regard to other minerals, the United States was in a better position than other industrialized countries, like Japan and the countries of Europe. In regard to food, the United States was one of the world's major suppliers. The report concluded that the United States can take the lead internationally in meeting the challenge of global scarcities and that "there is even speculation that the resource-rich United States may be returning to a position of political and economic pre-eminence comparable to that of 15 years ago."

* * * * * * *

This report was based upon hearings on the subject of the "global scarcities" which occurred in the 1970s. The world food shortfall, which first made itself felt in 1972, was followed in the fall of 1973 by the oil crisis. These crises prompted an increasing awareness of the growing interdependencies of the world's economics and the world's supplies of materials.

The report listed a number of criteria by which to evaluate the possibility of effective cartel-like action by materials producing countries, and concluded that such action by CIPEC (Intergovernmental Council of Copper Exporting States), the International Bauxite Association, or the International Tin Council was unlikely to have the international effect that the oil embargo by OPEC (Organization of Petroleum Exporting Countries) had in 1973.

The global scarcities of the early 1970s resulted from a "combination of economic developments and governmental policies."

The report went on to state that:

> For minerals other than petroleum, the principal factor was the failure of the world's productive capacity to extract and refine minerals to keep up with demand. Historically, economic boom in one part of the industrial world has been offset by the absence of economic growth in another part. During 1972–73, however, there was a convergence of unprecedented economic growth in the entire industrial world. The confluence had not been anticipated, and the world's productive

[1] U.S. Congress. House. Committee on Foreign Affairs. Subcommittee on Foreign Economic Policy. Global commodity scarcities in an interdependent world. Committee Print, 93d Congress, 2d session. Washington, U.S. Government Printing Office, 1974. 36 p.

> capacity was unable to keep pace with demand. The resultant inflationary trend was worsened by the tendency to hoard commodities, and the shortages had a domino effect, with scarcity of one item leading consumers to turn to others and cause further scarcities. (p. 9)

Factors such as the insufficiency of capital investment, U.S. price controls, and the overvaluation of the dollar reduced the competitiveness of U.S. products in the world market and further discouraged new industrial investment. The devaluation of the dollar in 1971–72 reversed that situation, but U.S. industry lacked the capacity to meet the sudden jump in foreign and domestic demand.

The report noted that this period of high international demand for, and the crisis in the supply of, materials coincided with the popularization of the "limits to growth" school of thought. This school emphasized the imminent (early 21st century) exhaustion of many or most of the world's critical materials based upon the inevitability of exponential growth using up the world's finite store of materials. Opponents of this view point out that technological improvements will make previously uneconomical mineral deposits profitable, increased prices will discourage waste, and recycling will conserve materials. These conflicting views of the basic availability of materials were unresolved at the time of the report.

In terms of U.S. self-sufficiency, the report stated that the Nation was a net exporter of raw materials until 1963. In 1964, the favorable balance of trade in minerals was reversed and the net deficit was $4 billion in 1969 and $8 billion in 1973. Of 63 key materials in the 1969–72 period, the United States imported 37 to a greater extent than 50 percent of total demand, and another 29 materials to more than 75 percent of total demand. (p. 11)

The United States imports large amounts of key materials, in spite of large domestic reserves of the materials, for economic reasons. One reason noted in the report was that the Nation had depleted many of its richest and most readily accessible deposits, so that some minerals could not currently be mined economically. Moreover, multinational corporations, most of them American, had been developing materials resources on a global basis, rather than domestically, to take advantage of cheaper foreign sources of supply.

In evaluating the U.S. minerals position, the report stated that: "No other mineral can affect the U.S. economy like oil." Generally, for minerals other than oil, the United States was in a reasonably secure materials position. In comparison with the nations of western Europe and Japan, for example, "the United States is in a much stronger position in that is produces domestically a much larger proportion of its requirements of raw materials."

The report also dealt with world food supplies. Global food scarcities in the early 1970s occurred at approximately the same time as other materials shortages due to the first decline in world food production in some 20 years and the simultaneous scarcity and rising prices of petroleum products. Petroleum products are necessary for agricultural production for chemical fertilizers, fuel for drying crops, and operation of agricultural machinery. "Agricultural supply and prices were also affected by government policies. The United States, Canada, and Australia, the principal suppliers in world food-stuffs trade, all had

earlier taken action to cut back wheat production in order to shore up prices * * *. By 1974, U.S. reserves were reduced to the lowest level since 1948—to a 26-day supply, compared to a 66-day supply in 1972, a 90-day supply in 1970, and a 95-day supply in 1961."

Like the debate between the proponents and opponents of the "limits to growth" thesis regarding world supplies of nonagricultural materials, the report stated that there was currently a debate regarding whether the global shortage of foodstuffs was an ordinary fluctuation in supply and demand of a temporary nature, or whether the agricultural supply scarcity was fundamental and long-lasting in nature. The following factors cited as indications that a fundamental change in world agricultural productivity had or was occurring included the facts that: except in some parts of the developing world, there was little potentially productive land that was not now under cultivation; most of the world's rivers that were potentially useful for irrigation had already been dammed; and petroleum supplies used for fertilizers and pesticides were becoming increasingly scarce and expensive. Moreover, there was increasing evidence of overfishing of the world's oceans and major shifts in the world's weather conditions. The report continued that:

> While the evidence bearing on these arguments is not yet conclusive, there obviously are some long-term warning signals and policy planners cannot base their judgments on the hope that food scarcities will be automatically corrected by one or two seasons of good farming weather. (p. 24)

The report summarized the principal policy issues related to energy, minerals, and food scarcities in the following terms:

> The effects of global commodity scarcities—in energy, minerals, and food—have been political, economic, and social. To mention only some of the more obvious: significant contribution to rampant world-wide inflation; severe shortage of key commodities, with impacts ranging from inconvenience and higher prices in developed countries to serious crop reductions in developing countries because of insufficient supplies of fertilizer and fuel; emergence of dissensions within both the EEC and NATO; introduction of new factors making inadequate traditional rules of international trade and international financial institutions; abrupt transference of political and economic power to a group of underdeveloped but resource-rich nations.
>
> The sudden emergence of global scarcities has brought with it a distinct awareness of the high degree of economic interdependence among the nations of the world. The old cliche of "international interdependence" has acquired a harsh reality. For the first time there is a realization that the world is dependent on common global resources—that there is a close connection between crop harvests in the United States, India, and the U.S.S.R. and the amount of world food supplies and even the price of food in the United States; that the United States has developed a high dependence on foreign sources of petroleum; and, that, even if the United States had ample commodity supplies, short falls in Europe and Japan could

> have severe domestic repercussions because of our close economic and political ties with them. As the world economy has become increasingly integrated, both through rising international trade and the internationalization of production, it has become increasingly difficult for one country to isolate itself from economic developments elsewhere. (p. 25)

The report stated that the most urgent need arising from global scarcities was the reconstruction of international rules governing trade relations; otherwise the alternative could easily be devastating trade and commodity warfare. In the field of energy policy, for example, the report suggests an "internationalized 'project independence.' " "It will serve little purpose for the United States to have sufficient supplies of energy if the economies of its major trading and investing partners, with whom our economy is closely tied, are hamstrung by inadequate energy supplies." In addition to developing new sources of energy supply through R. & D. on coal, oil shale, nuclear energy, and geothermal and solar energy, a second major problem was to find ways to "recycle" the massive sums of foreign exchange earned by the petroleum exporting nations.

The report continued that: "As regards U.S. policy toward other minerals, crisis is less imminent. The supply bottlenecks which were significant in the early part of 1974 have been eased and there is little prospect that either other commodities or the exporters of other commodities will cause problems of the magnitude that the world faces in oil. Nevertheless, the United States is in need of a strong policy aimed at avoiding cartel action and dramatic price increases in other minerals and at assuring adequate supplies to meet domestic needs." The report recommended reconsidering the use of the national strategic materials stockpiles for economic purposes, that is, to ensure the domestic economy of raw materials in case of abnormal shortfalls. The report also recommended improvement of the government's materials information systems and increased materials R. & D., recycling, and conservation.

In regard to agriculture, the report stated that the "primary goal of U.S. food policy should be the assurance of adequate world food supplies" through (1) the P.L. 480 foreign food aid program and (2) a long-term program aimed at increasing world agricultural productivity. A related food policy need was to increase world fertilizer production, which, of course, may be difficult because the petroleum raw products were a supply shortage problem in their own right. "Another policy which will help solve the long-term food problem is population control. The current world population growth rate will bring a doubling of world population every 25 years." The report also recommended that a system of world food reserves should be developed.

SUMMARY

The text of the report provided its own summary:

> The United States must assert vigorous international leadership in meeting the challenge of global scarcities. No other country is in a position to assume the directorship role * * *. The position is left vacant for the United States, and, if we

do not accept the challenge, it will go unfulfilled—and the result will be continued international chaos and threat of international recession and major disorders.

Relative to the other major developed countries, the United States is in a strong economic position in regard to global scarcities * * *. The U.S. supplies a high proportion of its mineral requirements from domestic sources and has benefited from commodity scarcities through high world prices for its agricultural exports, neither of which is true for either Japan or Western Europe * * *. There is even speculation that the resource-rich United States may be returning to a position of political and economic pre-eminence comparable to that of 15 years ago. (p. 36)

—Summary by William C. Boesman.

XV. PROBLEMS AND LEGISLATIVE OPPORTUNITIES IN THE BASIC MATERIALS INDUSTRIES

Analysis of a Report of a Panel of the National Materials Advisory Board, National Academy of Sciences [1]

The obstacles to innovation disclosed in this study by the National Materials Advisory Board of the four basic materials industries appear to be mainly institutional and financial. Perhaps these obstacles are an inevitable and inescapable concomitant of industrial maturity. Narrow profit margins, rigid corporate structures, and high replacement (or innovation) costs all tend to necessitate cautious policymaking. It is not evident that government action can force industry into more innovative patterns of behavior. Aging does not appear to be a reversible process, but there are some constructive actions open to the government to retard the process of aging and to ameliorate its consequences. Legislative consideration of these actions is a reasonable expectation.

* * * * * * *

INTRODUCTION

Assessment of the technological level of achievement of U.S. industries as compared with the levels of achievement in developed countries abroad poses knotty problems of analysis. Important differences are apparent in resource base, size of domestic market, geographical distributions of resources and markets, educational distribution and levels, availability of capital, size and quality of labor supply, societal acceptance of innovation, government-industry relations, and so on.

The participants in the study, "Problems and Legislative Opportunities in the Basic Materials Industries," rightly avoid a categorical answer to the question as to whether the United States is lagging technologically with respect to the industries examined: steel, wood, glass, and plastics. Technological level is clearly a situational matter. The admitted technical superiority of Japanese and U.S.S.R. whaling fleets is meaningless when the ocean runs out of whales. The superior skills of Detroit in building large cars are of diminished value in an oil-short world. Technological level, in sum, must be evaluated as to its effectiveness and appropriateness within the social, geographic, economic, and basic resource context where it is applied.

Moreover, the evaluation must address not the past but the present and even more importantly the future. In 1950 the United States produced half the products and consumed half the materials of the entire world. This was clearly a transient condition, as the war-devastated

[1] National Materials Advisory Board. Problems and legislative opportunities in the basic materials industries. Washington, National Academy of Sciences, 1975. 123 p. The report was prepared at the request of the Subcommittee on Science, Research, and Technology of the House Committee on Science and Technology.

countries began to recover and as the less developed countries began to industrialize. In relative terms, the United States has declined in production; it could hardly have been otherwise.

The reviving countries in Western Europe and Japan were sensible enough to examine their own situations instead of accepting U.S. technology uncritically as "the best." During German recovery, the low-stack blast furnace was emphasized because it had high productivity and low capital cost, and did not require high quality coking coal. In Japan, the maximum economy of scale is stressed in building large blast furnaces to achieve access to water haul, conserve space, and reduce production costs. In the United States units tend to be smaller because the market demands a wider variety of higher quality steels.

It is also evident that there is no easy answer to the question: are we solving our technological problems more cleverly than other countries are solving theirs?

The components of innovation include technical expertise, market demand, and industrial response. Research-intensive industrial sectors show strength in all three elements. There are roles for both large and small industry in innovation; there is also an important element of interdependence. Mobility and flexibility are essential attributes of the innovative firm. In the United States a large, effluent market is of great advantage in encouraging innovation. Strong emphasis is placed on management skill in the handling of the innovative process. The linkage between the universities and industry for basic research and manpower training is also important.

Options for government policy to encourage innovation center on eight objectives: ensuring competition, rewarding innovation, even-handed regulation to insure balance in costs and benefits, dispersed training and balancing of skills to need, use of procurement to advance socially needed technologies, encouraging job mobility of persons with technical expertise, designing a national science policy to encourage entrepreneurship, and liberalizing international trade.

Relative (but not absolute) emphasis on science education is higher in other countries than the United States, except for Japan where the greatest stress is on engineering rather than science. In the United States the enormous effort devoted to defense, space, and nuclear sectors obscures the fact that research and development in less exotic fields has been much more modest. Even so, the report concludes that "by and large, the U.S. civilian industries have not been at a disadvantage with respect to Europe or Japan," that levels of R. & D. effort are comparable, and that in other countries direct government support for civilian-oriented industrial R. & D. has not been large.

Technological leadership requires investment in research and development. To be first in any field of technological innovation is more costly than to be second. (Technology is almost always sold for less than its cost of acquisition.) In whatever areas of industry the United States aspires to lead technologically, it must out-invest its competitors in R. & D. in these areas.

But the study makes clear that as industries mature their ability to accept and exploit innovation diminishes. It is not the case of the tired old farmer who "ain't farmin' as good as I know how already." Size of industry has a ratchet effect that obstructs investment in innovation. Innovative opportunities are more abundant than is venture capital to put them to test. The challenge of the report is not to find ways to

increase the technical opportunities for innovation but to find institutional and financial means of enabling industry to innovate in ways it already deems attractive.

SUMMARY OF OVERVIEW CHAPTER (PAGES 1–9)

Many agencies of government are concerned with different aspects of materials in industry, pursuing different policies prescribed by Congress without any central coordination or resolution of conflicts.

Measured by the criterion of technology exports, U.S. basic materials industries lead technologically. This lead is judged to be insecure partly because of an asserted decline in U.S. investment in basic research supported by industry to advance its own processes and improve or develop its products.

Fundamental research related to industrial technology is being supported and coordinated by foreign governments, along with encouragement of commercial application of the innovations that grow out of such research. It is implied that the United States lags in this support and coordination, and that this Nation's economic position is thereby endangered.

Explicitly cited as constraints to industrial innovation in the United States are "government regulations on price, profit, safety, and environmental correction, as well as interpretations of antitrust laws * * *." It is contended that innovation is inherently risky, and that to encourage industrial innovation rewards (i.e., profit) should be made commensurate with risk.

A shift in research support has taken place: from industry to government. A major source of industrial R. & D. support is now the Federal Government. This shift imposes a burden of uncertainty on R. & D. because of "budget" fluctuations. Program stability and continuity appear to be an essential element of effective innovation.

SUMMARY OF CHAPTER I. "INTERNATIONAL COMPARISONS OF WAYS TO ENHANCE TECHNOLOGY" (PAGES 11–30)

This chapter accepts as a working hypothesis the necessity to "upgrade" the nation's technological process (progress?) in a given field through stimulating innovation. This upgrading requires a comprehensive or holistic approach, as a system. It encompasses education, research, venture capital, and institutions to provide for these. (The chapter is largely based on volume 4 of the appendices to "Materials and Man's Needs," the so-called "COSMAT" report of the National Academy of Sciences Committee on the Survey of Materials Science and Engineering.) Seven policies are listed as helping to stimulate innovation:

(1) Increased support for engineering education;

(2) Increased emphasis on civilian-oriented R. & D. joint industry-government research institutions;

(3) Fiscal incentives for private R. & D. investment;

(4) Self-supporting R. & D. research funding corporation;

(5) Government procurement practices to encourage innovation;

(6) Facilitating exports; and
(7) Foreign market development.

Funding of industrial research can come from government, from industry itself, or from both together. It is considered most effective for industry to do as much of its own research as possible, with the government providing incentives rather than funds. Research appropriate for government funding is that entailing high costs, high risks, and long duration. A further distinction can be made regarding joint public-private research: it should be beneficial to the consuming public, to the public at large, and to entire industrial sectors, especially where these sectors are composed of large numbers of small units.

Specifications for laboratories to conduct such R. & D. include:

(a) clearly defined mission addressed to consumer needs;
(b) larger than some critical minimum size;
(c) stable in funding and programing;
(d) coupled with or juxtaposed to university laboratories; and
(e) eventually self-supporting financially.

Only larger corporations can afford to maintain laboratories of adequate size and stability, and even these need explicit incentives to support their continued existence. There are various such incentives: "tax credits, elimination of sales taxes on specific products and services, accelerated depreciation, low-interest loans, and also outright grants * * *." Also patent protection, which the report judges to be inadequate in the United States. With respect to multinational corporations, the report notes that incentives for them to perform their research and development in this country are especially important. Otherwise, "they may find it more attractive to perform more of their research and development abroad."

Another possibility is the establishment of a "research and development funding corporation" to provide industry with venture capital and to support scale-up studies of new products and processes.

Market uncertainty is a major disincentive to innovation; one way to overcome it is through government procurement. This mechanism could be used to "encourage the continuing modernization of industrial plants and development of socially desirable new products and processes."

U.S. antitrust regulations are viewed in the chapter as a serious disincentive to innovation. The main charge is not that the regulations are necessarily onerous, but that there is uncertainty over their application. Accordingly the chapter suggests that "It might be useful if small occasional conferences were held, with the antitrust division of the Department of Justice, to try to establish criteria and ground rules for cooperative research in the materials area."

In contrast with a number of foreign countries, the United States has not developed government-industry "partnerships" to facilitate and encourage technology-based exports. This circumstance places U.S. industry at a comparative disadvantage in world trade, particularly in the development of innovative products for export. The report accordingly suggests that ways be sought to "aid firms and groups of firms in developing exports and foreign markets" by such measures as low-cost loans and tax incentives.

One effect of the various constraints cited above is said to make industrial research more and more short-range and unimaginative.

A decline in funding support is evident not only for industrial research in fundamental and long-range developments but also for the institutions that train students to carry on such work. Legislative attention is therefore invited to the need to:

Strengthen and stabilize government funding of research in fundamental science supporting civilian products and processes of interest to private industry;

Create new institutions to accept both public and private funding support to conduct and coordinate fundamental industrial research, and improve technology transfer;

Review and modify governmental regulations that hamper innovation and deter risk taking;

Recognize that career selection is a form of risk taking on the part of individuals, and that rewards should be commensurate: by increasing the rewards or decreasing the risk, to encourage more students into scientific or technological careers likely to produce technical innovations of use to society;

Support technical training institutions at all levels; and

Encourage retraining of technical people to translate obsolescent technical expertise into useful cross-fertilization in needed disciplines.

SUMMARY OF CHAPTER II. INTERNATIONAL TECHNOLOGY TRANSFERS AND MULTINATIONAL ENTERPRISES IN THE BASIC MATERIALS INDUSTRIES (PAGES 31–40)

The relevant question which this chapter was intended to address was whether the multinational corporation, as perhaps the most significant agency for the international transfer of technology, contributed to or detracted from the innovativeness of the basic materials industries with particular reference to wood, glass, steel, and plastics. However, the chapter was devoted mainly to the broader question as to whether the multinational corporation, engaged in direct investment in overseas production, was beneficial to the U.S. economy. The conclusion was that it was.

Despite this skewed emphasis, it is possible to derive from the chapter some useful information bearing on U.S. industrial innovativeness as related to the operation of U.S.-based multinational corporations. For example, the chapter observes that: " * * * The level of U.S. innovation is higher than it would otherwise be (i.e., in the absence of multinational corporations) since the possibility of a firm's exporting, making foreign investments, or selling licenses induces it to engage in certain research and development programs that would not be economical if the U.S. market were the only one considered." (There had been, however, "no systematic study of the relationship.")

One question not touched upon in the chapter is whether the U.S.-based multinational corporation receives full value for the technology it exports. The comparison is made that in amounts paid in royalties and management fees for all industries the United States received $3.6 billion and paid $0.3 billion.

The chapter goes on to point out that foreign direct investment is "primarily a movement of knowledge." The total of all types of income receipts plus retained earnings of U.S.-owned foreign affiliates, based partly on transferred technology, amounted in 1973 to some $14 billion.[2]

SUMMARY OF CHAPTER III.—THE FOREST PRODUCTS INDUSTRIES
(PAGES 41–66)

The purpose in selecting the wood industries as one of the four materials areas to be examined was that wood is a major industrial sector, with a long-established role, considerable diversity of products, involving many small companies, and extensively involved with technological change. It is a widely held opinion, however, that the wood industries—most notably lumber and plywood but less notably pulp and paper—are lagging technologically.

The analysis in this chapter begins by citing a long list of problems besetting the industry that are asserted to "have direct bearing on technological innovation." These problems are:

Shortage of raw materials.[3]
Fluctuating markets (especially the construction industry).[4]
Obstacles to technology transfer.[4]
Energy considerations.[4]
Cost of capital.[4]
Noncompetitive water-haul shipping costs.[4]
Fragmentation of the industry (especially lumber and plywood).[4]
Variety of raw material (as to both species and quality).
Reluctance to adopt technology developed elsewhere.
Environmental regulations.
The structure of the wood industry itself.
Market uncertainties.
International organization of individual companies.
Lack of seed capital for innovations.
Government patent policy.
Government antitrust policy.

Precisely why shortage of timber should deter innovation in the wood industries is not made clear. The logic of the situation would seem to require increased innovation, to make available supplies go further. However, it may be that the wood industries are beset with so many problems (shortage of wood being only the most salient of many) that the industry lacks both the incentive and the capital to exploit technology already available.

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[2] If these transfer payments reflected the true value of the technology exported, well and good. But if the technology was treated as a free good, or an add-on to other services, or if it was underpriced, then innovativeness is being sold short. If to this is added the technology dispensed freely under foreign aid programs, exchanges under bilateral agreements, and technology transfers to placate raw material supplying countries, the reward to U.S. innovativeness falls even shorter. If, for reasons of national policy, it is desired that U.S. technology be dispensed abroad at bargain rates, then a plausible case might be made that those who generated these intellectual properties should receive recompense from the Federal Government that determined this policy. If technology transfer is to be a diplomatic program in support of foreign policy goals, then the importance of sustained generation of new technology by and for private industry should be recognized; its dissemination without commensurate reward or support for its replenishment deters its further generation.

[3] Most pressing.

[4] Next in order cited.

For example, reference to the Jones Act (which requires U.S. industry to ship in U.S. bottoms between U.S. ports) is explained thus: "Certainly there is little incentive for a U.S. firm to innovate to become more competitive when a Canadian firm may adopt the innovation within a short period and continue his competitive advantage because of the Jones Act."

Another factor, fragmentation, means that "Except for the relatively few large firms, most companies find it difficult, given their relatively small size, to mount an effective research program." In addition, they lack the capital resource ("seed capital") to test out new technologies "until they have been well proven in use by others." Put another way: "A majority of the firms making up the forest products industries, because of their small size, their financial situation, and the difficulty they experience in gaining a unique advantage in the marketplace due to dealing primarily with commodity products, see little or no incentive in carrying forward a research and development program."

With particular respect to the pulp and paper industry, the cost of energy and the cost of installing equipment to satisfy environmental regulations have drawn away capital reserves that might (although not necessarily would) have been available for research and development. As the chapter remarks: "For the pulp and paper industry the availability and cost of capital is a major problem today." (And elsewhere, "individual companies are loath to expend funds on the development necessary to put new technology into practice.")

The chapter quotes an A. D. Little Corporation report listing as barriers to industrial innovation generally the following: marketing, finance, organizational problems within corporations, lack of seed capital for starting new high-technology businesses, and government policies and practices, e.g., in patent, antitrust, and regulatory matters. And the chapter observes: "all of these occur to some degree in the companies processing wood into products."

Apart from the suggestion implicit in the obstacles to innovation identified above, the chapter offers two specific options for legislative consideration. One of these, taken from the "Report of the President's Advisory Panel and Timber and the Environment," proposed that "Government and industry should conduct and support research to promote technological innovation in forest management and in wood utilization."

The other option, offered by the National Forest Products Association, calls for establishment of an "Office of Timber Growth and Utilization Research" in the U.S. Department of Agriculture. This office would be "dedicated to the transfer of technology in the forestry and wood utilization areas." Its functions, as set forth in the NFPA proposal, would be as follows:

> A. Contract for, sponsor and cosponsor application and development programs, including pilot plant and pilot process projects and economic feasibility demonstrations, concerned with the planting, protection and nourishment of forests; tree harvesting including thinning, feeling, ecological impacts and forest residues; conversion of trees into useful products, including sawmilling, peeling, drying, gluing, pressing and mechanical and chemical

fiber making; and improving efficiency of wood use including protection, systems design and innovation, recycling and waste conversion.

B. Encourage and, if necessary, contract for and sponsor research to fill gaps in supporting technologies which impede commercial development or implementation.

C. Promote coordination of federal, state and private forestry and wood research.

While encouragement of innovation in the wood industries appears on the surface to be a desirable course of action, it does not seem to provide a sufficient condition to overcome the identified "obstacles to innovation." It is the receptivity of the industry to innovation that is in question, rather than the technical opportunities.

SUMMARY OF CHAPTER IV. THE GLASS INDUSTRY (PAGES 67–82)

The glass industry is divided into five sectors: technical (pressed and blown glass), container, flat glass, fibrous glass, and optical glass. The chapter deals separately with obstacles to innovation in these five sectors, as follows:

Technical Glass

Here the R. & D. objectives are development of new compositions for special purposes, and novel melting and forming processes to meet specifications economically. Effort is currently diverted from R. & D. to reduction in pollution, securing fuel, seeking alternative raw materials, and "trying to maintain market volume in the face of rapidly shifting markets."

Some glass items (light bulbs for example) are assembled by the product manufacturer leaving the glass industry little scope for product development or innovation.

In the construction industry, glass offers many potential advantages but the traditional resistance of that industry to novel practices of design and construction discourages efforts by the glass industry to innovate.

Government patent policy "severely" deters innovation to solve technical problems in "instrument optics, nuclear energy, weapons, and national security" through fear of "mandatory loss of proprietary rights."

The industry is encountering difficulties in effecting the change over from gas fired to electric furnaces.

Possible options to encourage innovation in this sector include review of patent legislation, prompt assurance of adequate electric power, and creation of a glass and ceramic building products institute. This institution might be established within the Building Research Institute of the National Bureau of Standards. Its function would be to define appropriate products and applications; the industry itself would devise compositions and processes to make them.

Containers

Containers are a major sector of the glass industry, making 70 percent by weight and 40 percent by value of its product. R. & D. in this sector emphasizes process improvement, product improvement and safety, energy conservation, and re-use of cullet (fragmented glass).

The objective is mainly enhanced productivity. Barriers to innovation are (1) capital costs of modernization in a narrow-profit-margin, capital-intensive industry, and (2) government regulations. No special approach was offered in the chapter to enhance innovation; such generalizations were proposed as tax incentives, depreciation schedules, and overhauled regulations.

Flat Glass

The flat glass industry (sheet, plate, float, and rolled glass and products from them) primarily serves the construction and automotive industries. The flat glass process is dominated technologically by Pilkington Brothers of England. It is capital and energy intensive, sensitive to the availability of raw materials, and price competitive.

Innovation has focused primarily on energy conservation, health, and safety both in manufacturing of flat glass and its utilization by the architectural and automotive consumers. Considerable innovation also is concentrated on new products and process improvements.

Because of the nature of the flat glass industry, large capital investments are involved in innovation. The current money situation makes risk capital largely unavailable. There is also a considerable amount of duplication of effort due to the high degree of secrecy in this competitive industry, attributed in the chapter to antitrust regulations or concern for interpretations of such regulations. Two proposals are offered for options to improve innovation in this sector: (a) "the government should consider adopting an appropriate fiscal climate that will encourage innovation in the flat glass industry"; and (b) "consideration should be given to the establishment of a research center that would be charged with the investigation of those problems of a noncompetitive nature which are common to the entire glass industry."

Glass Fibers

This sector of the glass industry is characteristically highly innovative in its applications, marketed forms, and processing. Its product is used as an input in many products: glass-plastic composites, textile yarns, tire cord, and thermal insulation blankets.

Obstacles to innovation in this sector include: diversion of R. & D. effort from product development to energy conservation and pollution control, economic constraints compelling management effort to achieve short-term gains, uncertainties over environmental regulations, and difficulties in defining market needs.

Legislative options for enhancing innovation in this sector were suggested as follows:

(a) Realistic definitions and understanding by government of pollution problems and the choices which the industry and country must make.

(b) Recognition and some form of reward or stimulation for those companies devoting innovative efforts to solving energy problems.

(c) More capital made available by tax incentives for research and development.

In addition, the patent system could be strengthened by proper judicial recognition of the value of patents; and greater credit could

be given by the courts to the actions of the United States Patent Office in granting patents. Special recognition, as by accelerated write-off, could be given to patents related to pollution control and energy conservation. Recognition of innovators and the creation and maintenance of a proper climate for innovation could be a program supported by the National Science Foundation.

Optical Glass

Characteristically this sector converts low-cost raw materials into a high-value, small volume product, using expensive capital equipment. Obstacles to innovation include:

(1) High cost of development work for production of small volume in the face of market uncertainty and high interest rates makes amortization a serious risk;

(2) The tax treatment of multinational companies does not stimulate them to bring to the United States the new technology they find or develop abroad. Even relaxed tariffs on the importing of specialized forming equipment might ameliorate this situation since some very efficient grinding and polishing machines that are not commonly used in this country are available and used abroad. In the past, the large U.S. optical companies developed their own equipment, but the economic pressures to maintain existing equipment have resulted in their falling behind. Since this tendency to stay with obsolescent machinery is, in part, due to lack of awareness of developments in the rest of the world, encouraging the exchange of technical information through the dissemination of published materials and government-sponsored meetings might prove helpful.

(3) Present patent policies also discourage innovation in that too long a time often is required to obtain protection for new ideas. For example, the basic neodymium laser glass patent was filed in 1961 and issued in 1973, and no protection of or royalties to the inventing company could reasonably be expected during the 12-year waiting period.

(4) Marketing constraints to innovation include the lack of available information on market characteristics upon which to make well-informed decisions on need and risk for new products. Thus, another incentive to innovation would be to reward the risk-taker who is creating a totally new market in areas of national interest (e.g., pollution control, safety, energy conservation devices, or medical instrumentation). Many optical devices fall in this category, but it is difficult to obtain corporate support for new products when the market is diffused or inadequate market information is available.

The chapter suggests three sets of possible legislative options to enhance innovation in this sector of the glass industry:

(1) "Establishment of an industry research center (or centers), possibly patterned after the British Glass Industry Research Association or the German Max Planck Institutes, that would be responsible for development and dissemination of solutions in such problem areas as raw materials, the melting process, pollution abatement, and energy conservation." (Coupled with this proposal is a note as to the importance of resolving un-

certainties as to antitrust inhibitions in the operation of the center or centers.)

(2) Government assistance in meeting the costs of technological development through low interest loans, accelerated tax amortization, research grants, inclusion of R. & D. costs as a legitimate charge in government procurement contracts, subsidies for pilot plants, and "providing or guaranteeing a market at a reasonable price."

(3) A variety of expedients including special rewards for innovations serving national goals and improved market information services by the Department of Commerce.

SUMMARY OF CHAPTER V. THE STEEL INDUSTRY (PAGES 83–103)

The steel industry warrants particular attention because of its traditional role as the "basic" foundation of all heavy and light industry in the United States. While the automobile industry is often regarded as the bell wether of the U.S. industrial economy, the prime material it requires is steel. By far the largest metal in tonnage and range of applications, steel is indeed indispensable to industry. Accordingly, there is a tendency to view the steel industry as an index of industrial trends generally. The question of whether the U.S. steel industry is keeping pace with that of other developed countries therefore carries implications also for the comparative condition of other U.S. industries in competition with their foreign counterparts.

It is generally recognized that as an industry matures its individual units of production tend to become larger—to approximate the optimum in size to exploit economies of scale. As units of production increase in size, the rigidity of the entire system tends to increase: requirements for replacement capital for single units are large, requirements for modifications to meet pollution standards have a severe impact, and the industry's receptivity to innovations is limited by the large and sometimes risky investment in new capital required.

The steel industry's own view of itself tends to be ambivalent. On the one hand, there is an understandable pride that the U.S. steel industry leads all countries in tonnage, in range of alloys, and in quality of products.

On the other hand the industry has repeatedly expressed dissatisfaction with the hardships imposed on it externally, warning that its ability to maintain its leadership status is increasingly threatened. The chapter on the steel industry reflects this ambivalence.

Thus, on the one hand: "The United States does not lag significantly behind the rest of the world in the several kinds of technology employed in the steel industry, and the international market for new processes and products is thriving." In meeting the "requirements of U.S. customers who are constantly pressing for products of higher quality, closer tolerances, and other things that help them in their own operations," the chapter asserts, "there can be no doubt that the United States leads the world." And thirdly, "Regarding the sale of technology in recent years, the U.S. steel industry has been more active than anyone else."

However, these assurances that all is well must be balanced against a large number of indications that the industry is encountering increas-

ing problems in holding its own. Twelve such indications are offered in the chapter as follows:

(1) The industry faces a need for capital for replacement and expansion in the decade ahead * * * twice its requirement for 1963–72. Its ability to do this is in question.

(2) Innovations are limited primarily by economic considerations and costs of innovation are high.

(3) Earnings of the industry have declined substantially.

(4) The industry has been losing markets to foreign competitors.

(5) The industry relies increasingly on foreign alloying materials from increasingly insecure sources.

(6) Servicing the industry and shipping its product requires reliance on truck, rail, and water haul, in which stoppages could have serious consequences.

(7) Pollution abatement costs alone, to satisfy existing requirements, will amount to $3.5 billion.

(8) Although domestic reserves of metallurgical coal are adequate, there are many competing demands for it, and incentives to expand its output may be inadequate.

(9) Costs of raw material inputs are rising while prices of steel shipped are subject to "price controls in one form or another," subjecting the industry to a price squeeze.

(10) Domestic iron ore is diminishing in quality, and the industry is forced to rely increasingly on imports, in competition with other developed countries.

(11) Industrial practice in the use of energy evolved when energy was cheap; the rising costs of energy now confront the industry with the dilemma of paying more for wasted energy or adopting costly innovations to conserve it.

(12) The industry sees a need for more college-trained metallurgists than the universities are graduating, with the implication that the incentives to pursue a career in this field are inadequate, or inadequately perceived by entering students.

The chapter makes clear that the steel industry is remarkably open, on a worldwide basis, for the international transfer of technology. Each company adopts the technology appropriate to its particular geographic location, financial condition, supply situation, product lines, existing facilities, and pollution problems. That these conditions exercise constraints on U.S. innovativeness in the steel industry is evident.

The deteriorating financial condition of the industry appears to impose particular restraints. In the words of the report: "The financial constraints, specifically the high cost of bringing a process or product into commercial production, are the most important. The cost of the initial research is usually relatively small, but the cost of implementing a new concept or method is usually very great (i.e., invention is relatively cheap, but innovation—reducing the invention to practice—is very expensive)."

Apparently there are available many technologies that could advance U.S. steelmaking that are not being "reduced to practice" because of the industry's inability to finance them or its unwillingness

to take risks because the rewards—in terms of profit—do not warrant the hazard.[5]

The possibility that the risk and the expense of innovation might be shared by the entire U.S. steel industry appears to be foreclosed by antitrust regulations, either in actuality or as perceived by the industry.

The possibility is also raised that investment in technology might be distinguished, for tax purposes, into "investment in future technology" and "investment in present technology."

Legislative Options for the Steel Industry

Although as a general principle the steel industry favors reliance on market forces as the prime determinant of imports versus domestic production of materials, it warns against "a dangerous or costly dependence on imports."

Costs of prototype plants might be "expensed over the period of construction and startup." Projects too large for a single company to undertake might be supported by the government, and undertaken by a consortium or appropriate private organization. Canadian practice in supporting research also merits study. Review of both antitrust laws and their administration is suggested. Outlays for pollution abatement, being unproductive of income, might be made "deductible as incurred."

Government action is suggested to strengthen the serviceability of the large-volume transport upon which the industry is so heavily and intimately dependent. Concern is also expressed that the supplies of coal required by the industry might not be forthcoming without government action. While these suggestions deal less with innovation than with the health of the industry, the chapter makes clear that the primary inhibition of its innovativeness is its poor economic position which failure of transport, coal, or other energy forms could worsen.

A separate problem is the assertedly inadequate supply of metallurgists and mining engineers. Government support for correcting this situation is raised as a possibility.

A criticism offered in the chapter that because of the "sequential nature of present steel-manufacturing technology", the steel industry loses "over one-third of the energy used by the industry" is coupled with the technical suggestion that "processes [e.g. continuous casting] aimed at reducing the number of steps and novel techniques for recovering the heating values of waste gases provide opportunities for significant improvement in the efficiency of energy use."

In view of the important contribution of the steel industry to the U.S. economy, particular attention would seem to be warranted to

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[5] This CRS analysis calls attention to two developments not mentioned in this chapter that may have significance for the future of the steel industry in the United States.

(1) A recent study by a task force of the American Iron and Steel Institute, reported in Iron Age (issue of April 28, 1975, p. MP–13) described a major technological innovation that appears to offer important future advantages in terms of cost, conservation of fossil fuels, and pollution abatement. The concept calls for the use of a nuclear reactor to provide thermal energy, with fossil fuels as the reducing agent. A great deal of research and testing will be required to prove out the concept, and obviously these will be extremely costly. Federal assistance in advancing this technology might warrant consideration. According to one member of the AISI task force (T. F. Barnhart, Chief of the Process Analysis Division in the Research Laboratory of U.S. Steel Corp.) "We're already two to three years behind the Japanese and the Germans."

(2) Meanwhile, steel mills are being constructed in Saudi Arabia and Iran where natural gas is flared to get rid of it. Used as a "free good," such natural gas could lower the cost of steelmaking significantly in these countries. Technological action by the American industry might enable it to maintain its competitive position in the face of these challenges.

easing the barriers to U.S. innovation in steelmaking. Apparently the innovations are technological but the barriers are financial; it serves no useful purpose to invest in a vigorous campaign of research and development in new technology of steelmaking if the industry is unable to exploit it. On the other hand, unless the industry is somehow enabled to keep pace with technological advances worldwide it cannot be expected to hold its markets either abroad or at home.

SUMMARY OF CHAPTER VI. THE PLASTICS INDUSTRY (PAGES 104–109)

The plastics industry was included as one of the four materials industries to be studied, not because it is a stable and traditional industry but to provide a basis for comparison with a still-dynamic and expanding industrial sector. In recent years the plastics industry has been expanding nearly three times as fast as the GNP. It currently contributes nearly 2 percent to the GNP. Recent projections (with some qualifications) call for further expansion at twice the rate of GNP growth, to reach more than 7 percent of the GNP by the year 2000.

The growth and innovativeness of the plastics industry were attributed in the chapter to seven factors: (1) favorable raw material situation until recently; (2) automation and economy of scale; (3) ease of fabrication; (4) design flexibility; (5) wide range of inherent functional characteristics; (6) acceptable substitute for scarcer metals; and (7) capability of "tailormade" properties to meet particular engineering design requirements. In short, plastics are stated to be able to "perform many needed functions more simply and more economically than can competing materials."

The chapter addressed the question of what options are available to the plastics industry (and to government decisionmakers) to maintain a vigorous plastics industry in the face of an increasing shortage of natural gas and petroleum, today the principal feedstocks for plastics. It offered five such options, as follows:

(a) Recognition of the importance of plastics in the economy with allocation of the requisite amount of petroleum;

(b) Recognition of the ubiquity of plastics in the economy with the requirements that heat be recovered from waste plastics via incineration;

(c) Regulation of end use patterns (e.g., between the all-plastic bottle and the plastic-coated glass bottle or between plastic-coated paper and all plastic "paper");

(d) Legislation aimed at encouraging partial or complete use of renewable natural raw materials such as cellulose, alcohol, and oxygen; and

(e) Recognition of changing patterns in the world petrochemical production as the underdeveloped oil-producing companies move toward becoming major suppliers of petrochemicals and plastics from petroleum and consideration of appropriate trade legislation.

In taking up the question of innovation in the plastics industry, the chapter summarized the situation as follows: Historically, innovation has followed five basic patterns:

(a) Introduction of new basic types of plastic;

(b) Variations on these basic types;

(c) New ways to fabricate plastics into useful end items;
(d) New and more economical ways of producing the large volume plastics and the starting materials from which they are made; and
(e) Use of additions to modify properties.

However, "The very large demands on capital for worldwide expansion of the existing large-volume plastics hinders the introduction of any new product which is capital intensive." Thus, "* * * the potential new product is an inherent victim of scarce capital."

As an industry, its R. & D. effort is increasingly addressed to minor improvements in its marketability, rather than toward large changes in the product.

At the same time, national emphasis on environmental quality is having its effect: "Further increasing amounts of research and development manpower are spent in meeting the requirements—either existing or anticipated—of government regulatory agencies with regard to toxicity, ecology, flammability, and other aspects."

Legislative options suggested in the chapter to enhance innovation in the plastics industry include the following:

Promulgation of a national energy policy that, among other things, recognizes the "value of assuring the plastics industry ample supplies of oil and gas as feedstock materials";

Antitrust exemption of the plastics industry as a whole "to engage in joint research and development projects" to solve waste disposal and reuse problems;

Tax incentives "to encourage use of technologically advanced equipment" for the same purpose;

Clarification of the provisions of the Occupational Safety and Health Act;

Government cooperation with the Society of the Plastics Industry on problems of plastic flammability;

Joint public-private research and development efforts, and incentives (including "direct subsidies, tax rebates, and accelerated depreciation") to "encourage the maintenance of the competitive stance of U.S. plastics companies" in export trade;

Standard patent policy of Federal agencies to protect the right of the government, the public, and the innovating company;

Formation of a technical council composed of chief executives of technology-based companies;

Simplification of building codes on a national or regional basis, making them progressive and "open-minded"; and

Antitrust exemption for the plastic industry "to provide for a more comprehensive statistics program to give all interested parties a more accurate picture of market potential."

SOME CONCLUDING OBSERVATIONS

The obstacles to innovation disclosed in the study of the four basic materials industries appear to be mainly institutional and financial. Perhaps these obstacles are an inevitable and inescapable concomitant of industrial maturity. Narrow profit margins, rigid corporate structures, and high replacement (or innovation) costs all tend to necessitate

cautious policymaking. It is not evident that government action can force industry into more innovative patterns of behavior. Aging does not appear to be a reversible process, but there are some constructive actions open to the government to retard the process of aging and to ameliorate its consequences. Legislative consideration of these actions is a reasonable expectation.

—Summary analysis by Franklin P. Huddle.

XVI. FEDERAL MATERIALS RESEARCH AND DEVELOPMENT: MODERNIZING INSTITUTIONS AND MANAGEMENT

Summary of a GAO Report on Materials Policy, December 2, 1975 [1]

This General Accounting Office (GAO) report was instituted by two Senate members of the National Commission on Supplies and Shortages who were concerned with the funding and effectiveness of Federal materials R. & D. The GAO found that it could not properly evaluate whether Federal materials R. & D. was effective or not in the absence of a clear statement of national materials policy. The GAO concluded that a national materials policy did not exist, and that serious impediments to the development of such a policy were institutional and informational. Consequently, the report recommended that institutions should be developed to effectively coordinate Federal materials activities and to formulate policy and, relatedly, collect and analyze comprehensive and valid materials data.

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In this report which had been instituted at the request of two Senate members of the National Commission on Supplies and Shortages (NCSS), the GAO was asked to analyze Federal funding for materials research and development and to evaluate the effectiveness of Federal materials research and development. In attempting to carry out this study, however, GAO found that it had to look beyond the specific request and address the larger issue of national materials policy since a determination of whether existing materials R. & D. and materials R. & D. funding was effective would depend upon overall national materials policy.

GAO assessment of the current context of national materials policy was that the United States was the world's largest user of materials; it was becoming more dependent upon foreign sources of materials; environmental concerns were complicating materials supply, use, and disposal; and Federal materials program implementation was fragmented through some 23 Federal agencies and over 90 separate subdivisions thereof.

The GAO report examined major materials policy studies of the past and found many differences in emphasis and concern, and in time periods studied (short-term or long-term). One common theme they did detect, however, was the need for "an integrated system for describing and monitoring materials R. & D. activity. These reports have regularly pointed out the necessity for coordinating broad areas of work across narrow agency lines of authority."

The GAO report found that what was lacking at the Federal materials policy level "is an institutional capability, transcending indi-

[1] Comptroller General of the United States. Federal materials research and development: modernizing institutions and management. Washington, General Accounting Office, 1975. 68 p.

vidual agency concerns, for (1) continuously monitoring all aspects of the materials supply problem, (2) anticipating issues requiring policy decisions, and (3) accomplishing necessary analysis of alternatives in timely fashion."

Thus, in addition to examining materials R. & D., the GAO also examined (1) the Federal institutional framework for developing materials policy goals, and (2) materials information systems.

The GAO found that the basic governmental role to date had been one which sought to compensate for deficiencies in the domestic market (price) system. Given the structure of private resource markets, an active governmental role was considered necessary. On the one hand, care must be taken to avoid undue restraints upon materials production processes resulting from environmental regulations, tax policy, depreciation policy, and antitrust prosecution. On the other hand, the governmental agencies were engaged in programs, like resource conservation, stockpiling, promotion of international commodity arrangements, and R. & D., which would extend the life of known reserves or increase the supply of available materials.

The GAO also found that there was currently no system for assigning priorities to actions toward achieving national materials goals. There was no established institutional capability to assess alternatives and trade-off considerations between potential actions. The only coordinating body the GAO found was the Committee on Materials, an interagency committee under the Federal Council on Science and Technology, which lacked staff and authority to adjudicate differences between agencies and program options.

Like other recent reports on materials policy, the GAO report also stressed that research and development was not the solution to all materials problems. They felt that R. & D. activity was most appropriate only in relation to solving medium- to long-range problems of materials supply and efficient use.

GAO found that in three important areas Federal materials policy was seriously deficient. These areas may be summarized as follows:

> Program funding in constant dollars is decreasing;
> The Federal R. & D. effort is highly fragmented; and
> Data are incomplete and poorly gathered.

These three points are discussed in the following paragraphs.

While current dollar expenditures for materials R. & D. increased substantially between 1962 and 1974, from $185 million to $331 million, growth in real terms (constant dollars) was only about six percent. Between 1969 and 1974, real expenditures declined from $249 million to $206 million, or by about 17 percent.

An important conclusion of the GAO study was that implications of this decline cannot really be assessed in the absence of a materials policy framework. It cannot, for example, be demonstrated that more expenditures will give better results, nor is it possible to conclude that lower expenditures would be better.

The GAO also found that the current Federal R. & D. effort was fragmented. There was no overall Federal materials R. & D. program. Rather, there existed a large number of specific mission-oriented R. & D. activities. It would be unwise to assume that the sum of the activities of the 23 agencies and 90 subdivisions constituted a viable national materials program.

In addition, the GAO concluded that the collection of materials data over the last 15 years had been sporadic, incomplete, and insufficient for policy-making purposes. Proper management of the R. & D. component of a national materials program would be dependent upon a data information system to facilitate the assessment of activities from various perspectives. GAO determined that only the Smithsonian Science Information Exchange (SSIE) had existing capability to develop pertinent data. Using the incomplete information now in the SSIE, GAO for the first time, developed data related to the materials R. & D. phase of the materials cycle.

The Committee on Materials of the Federal Council on Science and Technology was engaged in the most serious effort up to the date of this study to secure good financial and related data from all involved agencies. If this activity proved workable, it could serve as a prototype for data collection upon which to base the needed expansion of the SSIE data base.

RECOMMENDATIONS

GAO made the three following recommendations aimed at modernizing the materials policy formulation process and the management of Federal materials R. & D. activity.

First, the Congress should consider establishing an institution to analyze national materials issues and provide policy guidance on a continuing basis. GAO further recommended that the National Commission on Supplies and Shortages assign a high priority to fleshing out the details of the proposed institution and providing its input to the Congress. At a minimum, such an institution should have basic responsibilities (1) to analyze policy options and trade-off considerations, and (2) to provide definitive guidance to operating agencies in planning for and executing materials policies, including materials R. & D.

Second, the NCSS should work with the Executive Office of the President to establish a comprehensive unclassified information system for materials R. & D. building upon existing information in the SSIE. The Commission should work with the Executive Office of the President in order to obtain mandatory Federal agency participation in the system.

Third, the SSIE should include in its information system data pertaining to private materials R. & D. as well as Federal Government materials R. & D. A properly balanced national materials R. & D. program cannot be developed without knowledge of activities underway in the private sector and university communities.

SUMMARY

The GAO report found that a coherent and comprehensive national materials policy did not exist. Federal materials activities were fragmented and interagency coordination was not very effective. Consequently, it was impossible to fully analyze Federal funding for materials R. & D. and to evaluate the effectiveness of Federal materials R. & D.

The report found that the serious impediments to the development of a national materials policy were institutional and informational.

The report recommended that institutions should be developed to effectively coordinate Federal materials activities and to formulate policy and, relatedly, to collect and analyze comprehensive and valid materials data. The report recommended that the SSIE be used as a framework upon which to build a thorough materials information system.

—Summary by William C. Boesman.

XVII. MATERIALS MANAGEMENT ACT OF 1975

Summary of Hearings Before the Senate Committee on Commerce, December 2 and 3, 1975 [1]

The Senate Commerce Committee held hearings on two materials information bills which would create new governmental institutions to deal with the related problems of materials shortages and materials information systems. Senator Tunney, who presided at the hearings, characterized them as the beginning of a national materials policy. Testimony on the bills broke down into support by government, academic, and non-industry representatives, and opposition by Department of the Interior and industry representatives who said that the bills would essentially duplicate existing information systems. Industry representatives further stated that the bills would represent a step toward a more federally managed and controlled economy.

* * * * * * *

These Senate Commerce Committee hearings were held on December 2 and 3, 1975 during the 94th Congress, first session to consider S. 1410 and S. 1415, bills cited as the "National Resources and Materials Information Act" and "Materials Information and Economic Forecasting Act of 1975" respectively.

Senator Tunney, presiding, characterized the hearings as addressing "the need for materials management, for streamlining materials information systems, and for establishing a coordinated materials research and development program."

The main approach taken by the Senate bills was to create a new Federal agency to deal with the problem of materials supply and shortages. S. 1410 (Senator Nelson) would establish an independent National Commission on Supplies and Shortages essentially identical with the existing commission, but which could continue in existence for up to three years (Sec. 811). A major function of this commission would be to establish a National Resources and Materials Information System which the commission would operate until such operation could be assumed by some new Federal agency (Sec. 821). This new agency, which would be independent of existing executive departments, would be under the control and direction of an administrator who would possess broad powers "to request, require, and collect resources and materials information from any person in such form and in such manner" as deemed appropriate by the administrator. Furthermore, the administrator would be empowered to "Coordinate existing resources and materials information collection activities of all Federal agencies."

S. 1415, sponsored by Senator Tunney, would establish a Bureau of Materials Forecasting as a mainline agency of the Social and Economic

[1] U.S. Congress, Senate, Committee on Commerce. Materials Management Act of 1975. Hearings, 94th Congress, 1st session. Washington, U.S. Government Printing Office, 1975. 309 p.

Statistics Administration within the Department of Commerce (Sec. 8). The bureau would be coequal with the existing Bureau of Census and Bureau of Economic Analysis. This legislation would also establish a Materials and Resource Information System to monitor the availability of products, materials, and resources (Sec. 4). The system would utilize pertinent data gathered by existing Federal agencies and, insofar as practicable, assign to the new bureau responsibilities for data collection and coordination.

In addition to S. 1410 and S. 1415, the committee also considered a "Staff Working Paper" of S. 1415 which essentially amended S. 1415 as summarized above by adding a title establishing a Council on Materials Management in the executive office of the President to establish and maintain the materials information system established by another title of the act, to establish materials research and development priorities pursuant to a third title of the act, and to review, appraise, and make recommendations with respect to the various materials programs and activities of the Federal Government affecting any part of the materials cycle.

In his opening remarks Senator Tunney said, "We must act now on a national materials policy. These hearings, hopefully, are that beginning * * *. The record we develop will provide a sound basis for proceeding with legislation to deal with the materials crisis."

The remaining sections of this summary deal with the testimony of witnesses at the hearings and with written comments and supporting documents.

HEARINGS TESTIMONY

Hon. Elmer Staats, Comptroller General of the United States, submitted written comments on the bills which included the following points:

> The S. 1410 provision to place the materials information system in the existing National Commission on Supplies and Shortages (NCSS) is probably preferable to placing it in the Department of Commerce, as required by S. 1415.
>
> Because energy materials present unique and extensive problems in their own right, the bills should explicitly exclude energy materials from the information systems, and a separate information system should be established for these types of materials.
>
> In regard to the centralization of materials information, the principal objectives of the unified System should be to supplement and not supplant existing agency systems and to strengthen overall governmental capability for monitoring, evaluating, forecasting and policy planning through systematic improvements in the collection, standardization, comparability, coordination and dissemination of economic and materials information. (p. 96)

In oral testimony, Staats stated that existing materials information systems generally were not geared to serving broad national program objectives. He emphasized that institutional change is required for adequate materials policy formulation at the Federal level, and summarized the GAO recommendations contained in the report, Federal

Materials Research and Development: Modernizing Institutions and Management [see summary, No. XVI in this report]. As noted above, the GAO supported the S. 1410 provision to place the materials information system temporarily in the NCSS, and "considering the many Federal agencies which deal with materials problems, the least desirable option would be to assign the responsibility to a single existing bureau or department." The GAO would also support the establishment of a Department of Energy and National Resources and the establishment of a Cabinet-level Council on Materials for materials issue analysis and policy information.

Staats said that there were currently no Federal priorities for materials policy. When asked by Senator Tunney to identify his (Staats) first priority, Staats said that it would be to make full use of the existing Smithsonian Science Information Exchange (SSIE) system for developing a comprehensive materials information system.

Dr. Jack W. Carlson, Assistant Secretary of the Interior for Energy and Minerals, testified before the committee and submitted additional written comments. The thrust of his testimony and comments was that the proposed legislation, S. 1410 and S. 1415, would "duplicate many of [the Secretary of the Interior's] responsibilities under the existing legislation * * *. Moreover, we believe that the existing mechanisms for interagency consultation, such as The Domestic Council, The Council on International Economic Policy, The Economic Policy Board, The National Security Council, and the Cabinet are fully adequate to devise workable programs for meeting national needs and that the creation of additional bureaucracies would not be in the public interest." Earlier in his remarks, Carlson also mentioned the interagency Committee on Materials (COMAT), under the Federal Council on Science and Technology, as another effective group concerned with coordinating Federal materials policy.

Carlson commented that the "Bureau of Mines is the focal government agency for the collection, analysis, and dissemination of detailed information about mineral reserves, production, and uses, covering not only the United States but the entire world as well." Carlson also detailed the individual and overlapping data collection programs of the Bureau of Mines and the Geological Survey of the Department of the Interior and mentioned that the Department of Commerce has responsibility in terms of the materials that go into manufacturing and to the ultimate consumer.

Mr. John Kyl, Assistant Secretary of the Interior for Congressional and Legislative Affairs, in written comments, stated that the Department of the Interior recommended that S. 1410 not be enacted because the "data-gathering provisions of S. 1410 appear remarkably similar to the data banks which currently are in the process of development within the Department" and that S. 1415 not be enacted because "most of the functions described in S. 1415 have already been assigned to the Departments of Agriculture, Commerce, and Interior and the Federal Energy Administration."

The major points of difference between Staats of GAO and the representatives of the Department of the Interior seemed to be that GAO perceived the need to coordinate more effectively Federal ma-

terials programs and believed that this could be done only through the assignment of that responsibility to a new organization, whether temporarily to the NCSS, or permanently to something like a Department of Energy and Natural Resources. On the other hand, the Department of the Interior representatives saw such a new organization as redundant and an addition to an already large bureaucracy in the area of materials. The comments of Senator Tunney seemed to imply his support of the view espoused by the GAO over that taken by the Department of the Interior representatives.

Mr. Marvin Caplan, of the Industrial Union Department (IUD) of the AFL–CIO gave that organization's view on the proposed legislation. The IUD was particularly interested in materials availability and materials policy in regard to ensuring a high level of employment in materials-related industries. Caplan stated that:

> The measures which this committee is considering [S. 1410 and S. 1415], specifically the proposals for a national materials information system, for support for materials research and development, and for the establishment of an effective national policy coordinating body within the executive branch, are welcome developments in what has up to now been a policy vacuum. (p. 157)

Most of Caplan's comments concerned a report prepared for IUD by the consulting firm of Ruttenberg, Friedman, Kilgallon, Gutchess & Associates entitled "Raw Materials for America, a Program To Assure Meeting Future Needs." The report had both "good news and bad news." The good news was that there is no need for panic, the world is not going to run out of all the industrial raw materials it needs in the near future, and the Nation is not as vulnerable to cartel actions as has been feared, but "this is so only if we develop and carry out a much more definitive materials policy than we have had."

The bad news as given in the report involved the following three points:

> The continuing mismanagement by government of materials policy;
>
> The growing tide of corporate multinationalism which can shield the exploitation of the world's resources from effective national government control; and
>
> The irreversible and irrepressible movement by third world countries to redistribute the world's wealth and to gain a larger share of the total for themselves.

In the area of government "mismanagement" of materials policy, Caplan mentioned "first and foremost * * * the conspicuous lack of focused government attention to the problems of raw materials supply." He mentioned the long history of commissions established to study materials policy and the existing diffused government responsibility for materials policy, stating that the "new Commission on Materials and Shortages [National Commission on Supplies and Shortages] will fare not better than its predecessors unless there is an identifiable focus of government responsibility in this area." Other areas of "mismanagement" cited by Caplan included materials exploration and R. & D. where government support has been minimal;

counterproductive policies which encourage waste rather than conservation, like incentives to use virgin rather than scrap materials; the lack of effective strip-mining controls; an apparent disregard for the development of a clearly stated seabed policy; the use of the existing strategic stockpile for nondefense purposes, specifically for economic and political purposes; and the uncoordinated response to the third world movement to redistribute the world's wealth, the so-called "new economic order."

In the area of growing corporate multinationalism, Caplan noted that the materials industry was marked by a substantial concentration of vertically and horizontally integrated multinational corporations in a few large fields. For example, in 1969 six companies produced three-quarters of the world's aluminum; ten companies produced two-thirds of the world's copper; and four companies produced 98 percent of the world's nickel. The majority of these companies were American. Caplan stressed that the "MNC's [multinational corporations] are clearly more concerned with maintaining their relationships with the host country than they are with meeting economic and social responsibilities at home."

In the area of the movement by third world countries to redistribute the world's wealth, Caplan cited as examples a number of new materials cartels (the International Bauxite Association, CIPEC—the association of copper producers, the Association of Iron Ore Exporting Countries, and the International Tin Council), and the movement by many developing countries to develop materials fabricating facilities within their own borders and to sell the developed countries processed materials, at a higher cost, than the basic raw materials they are currently selling.

With these report findings before them, the IUD proposed a ten point program to cope with present and future threats to American access to industrial raw materials. Briefly, these ten points concerned specific international agreements with supplier nations; the establishment of a Federal agency to mobilize materials R. & D.; the development of seabed materials; the establishment of economic stockpiles; the building of standby facilities to produce and process materials; the removal of tax disincentives for locating manufacturing facilities in the United States; enforcing appropriate antitrust laws to prevent domination of the materials industry by a few major corporations; expansion of conservation measures; support of a strong maritime industry; and the establishment of a Federal commission on national resources. Since the proposed legislation (S. 1410 and S. 1415) addressed the second and last points, the IUD supported the legislation.

The remaining discussion between Senator Tunney and Caplan concerned the possible negative effect that multinational corporations may be having on the development of a national materials policy through their influence at the highest levels of government.

Professor Morris Cohen, of the Massachusetts Institute of Technology also appeared as a witness. Professor Cohen was the Chairman of the National Academy of Sciences Committee on the Survey of Materials Science and Engineering (COSMAT) which produced a report on materials science and engineering (MSE) entitled "Materials and Man's Needs." [see summary no. XII in this report.] Pro-

fessor Cohen stated that he strongly supported S. 1415. His discussion was mainly a summary of the major points discussed in the COSMAT report, like the fundamental nature of the materials cycle, the materials-energy-environment interactions, the interrelatedness of materials policy with economic and political decisions, and the importance of MSE. Professor Cohen's support of S. 1415 seemed to be rather uncritical, that is, he supported the major provisions of the bill without analyzing existing or potential alternatives or possible redundancies.

Dr. J. H. Westbrook, manager of materials information services of General Electric Company, testified as to what he believed to be the "desires of private industry for Federal assistance in materials information, or at least that portion of private industry that is a consumer of materials." Westbrook stated that "we now have a national materials information system and one that is working surprisingly well. It is imperfect, pluralistic, replete with redundancies, gaps and inaccuracies, but it is working." He claimed that current interest in a Federal materials information system was due to situations like the Arab oil boycott and because "access to the national materials information system is now sought by elements of our society not professionally trained in materials, something it was not designed for." It was not clear to Westbrook that a new, large Federal materials information system devoted mainly to the accumulation of data on supply and demand of materials was the optimum or even an acceptable solution to the existing materials problem. Rather than design an entirely new materials information system, Westbrook would correct deficiencies in existing materials information systems by improving: data usefulness and use; Federal support for informational systems; cooperation between firms using materials information through reformation of laws prohibiting such cooperation; and competent evaluation of such information.

Because the proposed bills dealing with materials information primarily address questions of supply and demand, Westbrook stressed that many shortages were not due to any lack of material, but were due to such factors as price, lack of processing facilities, lack of the proper grade of the material, impact of a foreign political event, and U.S. Government actions like price controls. Consequently, he suggested that what industry needed in the way of governmental support in the materials information field was the following:

> Assistance in reducing the significant redundancy in private materials information through positive governmental incentives for cooperative action and for reducing the barriers that exist to private cooperation, like antitrust legislation;
>
> Assistance in creating computerized materials information systems that are beyond the resources of individual private firms; and
>
> Government provision of materials information related to knowledge of materials properties required by governmental regulations like those of EPA and OSHA.

Westbrook commented that the supplement to S. 1415 filled some unmet needs for a "coordination, monitoring activity to look at the whole government involvement in materials * * * [and] in envisioning for the Department of Commerce a role of its own in materials

R. & D. that would be distinct from, but coordinated with, that of the various mission agencies, Defense, HEW and so on."

Mr. Bernard M. Sallot, director of technical activities of the Society of Manufacturing Engineers, testified as to the special problems of manufacturing engineers in regard to materials information. He stated that the development of manufactured products often involved three to five year lead times and the expenditure of millions of dollars. Commercial success of manufactured products hinges on the stability of materials selection and supply. Until the recent oil crisis, the fulfillment of the production process depended on good design of product, good selection of processing, and the availability of materials at the end of the lead time to begin manufacturing operations. Normally this occurred with reasonable certainty. "This is no longer so in the current climate of inflation and capital shortages * * *. Non availability of material (or energy) at point of manufacture wipes out the huge investment along with the jobs of millions."

Sallot further noted that information regarding materials availability was often unreliable and for that reason he basically supported S. 1415. He stated that:

> We do not advocate a materials czar or centralized planning. We do believe that we should have more information available for decentralized planning, that we should have a better understanding of the flows of key materials into and out of the United States, and of how these streams would be modified under various political conditions, including war.
>
> We need to know not only the streams entering and leaving this country, but how they interact with the streams for and from other countries. (p. 188)

In summary Sallot, speaking for his organization, recommended:

> The establishment of a central materials agency, on a top policy and implementation level which would include: (1) Existing agencies, departments, groups, etc., and (2) new groups, where areas are not now adequately covered whose function would be: (a) the conception and implementation of a national materials information collection, analysis, and dissemination system, and (b) by use of existing information and information to be gained from the new network to recommend, coordinate, and fund a research and development program designed to enhance (and protect) the supply, the efficient utilization, and the substitution of materials necessary to our present and future production process. (p. 189)

Dr. John B. Wachtman, Jr., then OTA's program manager for materials, discussed OTA's current assessments in economic stockpiling, materials accessibility, and materials information systems.

Dr. George Eads, executive director of the National Commission on Supplies and Shortages (NCSS), testified that the NCSS saw the institutional problems related to materials policy as its main focus. Specific problems often mentioned with the formulation of national materials policy included: materials policy decisions lack a long-term perspective due to excessive reliance on market forces; decisionmakers

lack the necessary information upon which to base policy; and the decision-making process is fragmented, uncoordinated, and lacks a means of harmonizing dissonant points of view.

Because the commission had not become fully operational at the time of the hearings, Eads submitted a letter from Senators Mansfield and Scott (Pa.) as to the major purposes of the commission. Part of this letter stated:

> We have reviewed the enabling legislation. Reflected there is the agreement we all had as to the objectives of the Commission. Basically they are twofold: (1) To determine what current actions are necessary to meet upcoming economic requirements for resources, commodities, materials and manufactured products, and (2) to determine what institutional adjustments (including even "establishing an agency") are needed in the Nation to provide a coordinated strategic economic information system and to analyze economic needs (for resources, commodities, materials and manufactured products) on a permanent basis.
>
> To keep these tasks in perspective it may be well to remember that past Commissions have undertaken exhaustive investigations as to the manner by which the economy of the Nation is integrated, how shortages therein arise and related matters. These questions have been studied to death, so to speak. What is needed most at this time and what we all agreed was of paramount importance is to at long last implement the major recommendations of past studies—designing the appropriate instrumentality that can provide strategic economic information assessments together with specific policy options that might be employed today to help mitigate or prevent the crisis, if any, perceived on down the road. (pp. 193–4)

Eads stated that it would be important to classify types of shortages and their causes; to examine specific shortage situations and identify those cases in which market forces failed to generate the proper signals or where such signals were distorted; and in general to identify those types of shortages that would best be left alone by government and those types where government actions might play a constructive role.

Senator Tunney and Eads discussed the inadvertent making of materials policy through uncoordinated government actions, many of which work at cross purposes. Eads saw as one of the responsibilities of the NCSS the task of straightening out the actual process of making national materials policy.

Dr. Harvey Brooks, professor of technology and public policy at Harvard, testified in regard to the materials information aspects of S. 1415 as follows:

> Any management system in my opinion must rely in a major way upon the market, and government intervention should be confined, it seems to me, to four areas: (1) Providing information that will help the private sector in anticipating future trends and acting accordingly; (2) stimulating basic

> and applied research on the more fundamental and generic aspects of materials, so as to provide principles, theories, and techniques with which private organizations can better design their materials development strategies for specific markets and end uses; (3) assisting in the setting of specifications and standards for materials properties; and (4) regulating the materials cycle with respect to environmental impacts, either through standards or through alteration of economic incentives. (p. 199)

Brooks also discussed the materials R. & D. aspects of the bill and the relative merits of locating such responsibility in the NBS or the NSF. He felt, on balance, that it would be better to locate the responsibility in the NBS. In regard to coordinating materials policy, Brooks said that there was a need for a "more overarching coordinating mechanism" than currently existed in the Federal Government and that S. 1415 did more than just duplicate materials information systems that currently existed in the Department of the Interior and elsewhere in the government.

Mr. Simon D. Strauss, testifying on behalf of the American Mining Congress, said that since the NCSS had just begun its work, it would be premature to react to S. 1410 and S. 1415. He did comment that although the American Mining Congress recognized the desirability for a coordinated approach to gathering and recording information already being collected by various Federal agencies, he questioned whether the addition of still another organization would improve matters. Furthermore, he stated that "some of the legislation proposed seems to us to give far too much discretion to appointed government officials in the securing of information of a confidential nature from private enterprises which these officials could subsequently make based on unilateral determination. This appears to us to be a further invasion of the right to privacy by government, a subject already causing grave concern in many quarters."

Going on to more general matters, Strauss said that the American Mining Congress believed that a widespread repetition of situations like the oil crisis was unlikely in other materials. In commenting upon provisions of the bills to forecast long-range materials needs, Strauss said that "if the government forecasts a potential shortage in some material, that forecast may well tend to become a self-fulfilling prophecy, at least over the near term," and he cited examples of panic buying and sharply rising prices. "It seems to us * * * that the [NCSS] will need to ponder very carefully the advisability and the circumstances under which official government forecasts of impending shortages should be issued." With respect to information gathering, Strauss stated that "the mining industry believes that in the U.S. Bureau of Mines the government already has an effective and capable organization to gather the essential facts with respect to mineral materials."

Strauss summed up his testimony by saying that what was really needed to improve U.S. materials self-sufficiency was "an overall examination of the costs and benefits to the public of matters now bearing heavily on the health of the domestic mining industry." These included environmental regulations, surface mining and the restora-

tion of mined-out areas, access to public lands for mineral exploration and exploitation, and the issues of tax incentives.

ADDITIONAL DOCUMENTS

A number of additional articles, letters, and statements were appended to the hearing proceedings. Most industry comments contained the position that S. 1410 and S. 1415 provided mechanisms that unnecessarily duplicated existing capabilities, such as those of the U.S. Bureau of Mines and the U.S. Geological Survey, or were a first step along the road to an increasingly controlled and regulated economy.

Senator Nelson, author of S. 1410, in written comments, emphasized that the major difficulty in passing S. 1410 would be the provisions relating to access by government to private, proprietary information:

> The stumbling block, in a word, is access. The issue, in a sentence, is "To what proprietary information should a National Resources and Materials Information System be given access, and what persons and classes of persons should be given access to such information within the System?"
>
> That is the question without a good answer to which this country will never get the National Resources and Materials Information System it so badly needs. (p. 254)

The other big issue with the bills noted by Senator Nelson was the decision as to where in the Federal Government the information system should be located.

Several witnesses from private non-industry organizations and academia stated that the purposes of S. 1410 and S. 1415 seemed to be very much in line with the recommendations of the final report of the National Commission on Materials Policy, the COSMAT and COMRATE reports of the National Academy of Sciences [see summaries XII and XVIII in this report] and similar recent materials policy studies.

SUMMARY

S. 1410 and S. 1415 dealt with the establishment of a comprehensive Federal materials information system and with a mechanism for effectively coordinating existing, far-flung Federal materials agencies which had been recognized by government and industry alike as being highly fragmented and rather ineffectual for the formulation of national materials policy. Senator Tunney characterized the hearings on these bills as a first step in the development of such a national materials policy.

Testimony and comments on the bills seemed to break down according to two basic categories of persons. Government (with the exception of the Department of the Interior), non-industry, and academic representatives generally agreed in principle with the need for the institutional adjustments embodied in the bills, although they differed on details. Industry representatives stated that (1) the new governmental institutions and informational system envisioned by the bills were largely duplicative of existing informational systems and (2) even more importantly, seems to be a first step toward a more federally managed and controlled economy. Department of the Interior representatives agreed with the first point expressed by the industry representatives.

—Summary by William C. Boesman.

XVIII. MINERAL RESOURCES AND THE ENVIRONMENT

Summary of the Report of the Committee on Mineral Resources and the Environment (COMRATE) 1975 [1]

COMRATE was a standing committee of the National Academy of Sciences-National Research Council established to study problems affecting mineral resources and the environment. This COMRATE report was prepared by four panels of experts which dealt with the following interrelated materials problem areas: materials conservation; estimation of material supplies; estimation of demand for materials; and the implications of mineral production for health and the environment. Each panel of experts set forth specific recommendations in its own area. The report's executive summary set forth general conclusions to the effect that general knowledge as to materials supply and demand, and effect on health and the environment, is at such a low level that policymakers would be best advised to adopt a "materials conservation ethics" and concentrate on trying to get better information in the field of materials so that materials policy can be developed on a sound basis and not upon erroneous data and fallacious methodologies.

* * * * * * *

The concept of COMRATE as a standing committee of the National Academy of Sciences (NAS)-National Research Council—to provide ongoing, balanced, long-term review of problems affecting mineral resources and the environment—was approved by the NAS governing board in September 1971. This COMRATE report was prepared by four panels of experts to deal with four interrelated materials problem areas, that is:

Materials conservation through technology (by the technology panel);

Estimation of mineral reserves and resources (by the materials supply panel):

The implications of mineral production for health and the environment: the case of coal (by the environmental panel); and

The demand for fuel and mineral resources (by the materials demand panel).

Each panel approached its area of investigation in a different way. The technology panel covered its entire area in a fairly comprehensive manner. The materials supply and environmental panels took case-study approaches, looking at (1) fossil fuels and copper and (2) the health effects of coal production, respectively. The materials demand panel took a rather generalized approach to its area of investigation. In addition to the findings and recommendations discussed in the

[1] Committee on Mineral Resources and the Environment (COMRATE). Mineral resources and the environment. Washington, National Academy of Sciences, 1975. 348 p. [With four separately bound appendices]

COMRATE study itself, as summarized here, each panel prepared an appendix of supplemental and supportive information under separate covers.

The COMRATE report thus dealt with the complex interrelationships between materials supply and demand, technology, and effects on the environment. The report identified the fundamental dichotomy in the current understanding of this interrelationship and briefly discussed the unresolved conflict between those persons who saw a future in which catastrophic exhaustion of resources was inevitable unless drastic measures were taken to reduce economic growth (the "doomsters") and those who maintained that mineral resources were economically and, for the foreseeable future, physically infinite (the "cornucopians").

While not ascribing to either extreme view, "COMRATE believes that the United States will face serious difficulties in attempting to increase some supplies of energy and mineral raw materials from domestic sources. Indeed, COMRATE believes it is doubtful whether even current levels of supply can be maintained for all materials."

The principal themes of the COMRATE study were interrelated. In fact, the first and perhaps major theme of the report was interdependence, that is, that no aspect of materials policy could be considered in isolation. Another important theme was that a materials conservation ethic should be encouraged. Two other themes were reminiscent of the COSMAT study—(1) materials move in complex ways through a total materials cycle and (2) materials must be considered and addressed as part of the materials-energy-environment triad. Two other principal themes of the COMRATE report were that materials policy affects, in interdependent ways, (1) the interests of government, industry, and the consumer, and (2) both national and international policy. This complexity and interrelatedness suggested the need for a systems approach to materials policy, also emphasized in the COSMAT study. The COMRATE technology panel stated—only in regard to the problems of materials technology, but the message has general applicability—that:

> It must be recognized that the more complex and ramified the field of technology the more the need for a systems approach which in turn requires unified responsibility. (p. 25)

General Conclusions

The COMRATE report, as noted above, was really the separate reports of the four panels. However, the following general conclusions were drawn in the Executive Summary Introduction section of the report:

> Mineral resources become available for man's use by a complex and lengthy process which, on a worldwide scale, relates intimately (a) natural process (b) man's knowledge and technological ingenuity, and (c) man's economic, social, and ethical concerns. Efficiency in use and avoidance of waste in both mineral resources and their end products are essential to alleviate immediate economic strains, and are even more essential if we are to avoid preempting the resources needed for future generations. Policy making at all levels should recognize interdependencies within the materials cycle, among

nations, and among the various users of mineral commodities. But, above all, we should adopt a conservation ethic that has at its heart avoidance of waste and more efficient use of materials.

Widely divergent methodologies, based largely on individual judgment, are used both in forecasting demand for, and in estimating supplies of, mineral resources. There are currently no standardized techniques for making either long-term demand forecasts or resource estimates nor are means available to assess adequately the accuracy of the existing methods.

Reliable data on mineral resources are difficult to obtain because of their proprietary or international nature. This affects supply estimates. In the United States much improvement is still needed in the work of the U.S. Bureau of Mines and the U.S. Geological Survey in the collection, coordination, standardization, and dissemination of mineral resource data.

Definitional vagueness and numerical imprecision afflict discussion and publications, both inside and outside government, concerning mineral resources. The notions of reserves and resources used in this report, which were recently formulated for use by the U.S. Bureau of Mines and the Geological Survey, could also serve as a common frame of reference for all resource discussions. Units of measure used for resources are diverse and cumbersome. Recognizing the interdependence of resources, common scales for units and for quantities should apply to resource estimates. In addition, the gathering of resource data should be refined and systemized so that standard error or confidence level appreciations can be applied as elsewhere in the physical sciences. (pp. 3–4)

REPORT OF THE PANEL ON TECHNOLOGY

The basic theme of the technology panel report was interdependency (1) within the materials cycle of materials-energy-environment, (2) within the international system, and (3) between the social and technological aspects of materials availability. The panel concluded that technology would not be able to close the growing gaps between rising demands and limited supplies of mineral resources. Consequently the panel concluded that the Federal Government should pursue a national policy of resource conservation.

The panel made twelve policy recommendations that government and other organizations take the following steps:

Pursue a national policy of conservation of materials, energy, and environmental resources;

Obtain the concerted advice of technologists and social scientists;

Take a systems approach to the materials cycle and the materials-energy-environment system;

Seek equitable international agreements concerning the exploitation and sharing of materials resources;

Practice stockpiling of materials and of the technology for acquiring them from domestic sources;

Facilitate industrial cooperation to minimize waste of natural resources;

Find ways to share the scale-up costs of materials technology in areas of high risk or delayed payoff;

Endeavour to increase the amount of trained manpower available to the materials industries;

Support an intensive program to develop automation for the materials industries;

Sponsor intensive studies of the effects of waste heat and pollutants on climates and ecosystems;

Develop data giving the energy and pollution consequences of recovering values from ores; and

Create an institutional capability for long-range forecasting of materials issues and taking appropriate actions. (p. 18)

The panel also made thirty-nine specific technological recommendations in the following areas of: energy; pollution control; mineral exploration; mining; beneficiation (processing to improve the physical and chemical properties of minerals or to concentrate or otherwise prepare ore for smelting); primary metal production; recycling; product design; and substitute materials.

The panel believed that although the private sector should retain the main responsibility for developing technology, Federal participation was often inevitable and desirable. Four especially important roles for the Federal Government were (1) broad guidance of the national economy from an era of material growth to an era of material conservation, (2) guardianship of the environment and stimulation of more effective utilization of materials and energy (realizing that clumsy, hasty, or over zealous regulation of standard setting can be more injurious to the economy, environment, and standard of living than the conditions they are meant to alleviate), (3) stimulation of technology transfer from the R. & D. phase to commercial use, and (4) regulation of industry in the public interest, by creating opportunities within a broad framework of individual and corporate enterprise.

REPORT OF THE PANEL ON SUPPLY

The supply panel stated that "it is essential that the best possible estimates of reserves and resources of minerals be available. Such estimates are a first and necessary basis for national policy with regard to minerals." The panel concluded that a major problem in improving estimates of materials supply was the difficulty of bringing into the public domain proprietary information gathered by private organizations and combining it effectively with governmental information. A second deficiency with current resource estimates was inadequate recognition of the economics and possible rates of mineral production and processing.

The report dealt mainly with reserves and resources of fossil fuels and copper and concluded (1) that U.S. independence from external sources of fossil fuels was "essentially impossible on the basis of increased [U.S.] production of petroleum during the next decade, and

that a strong emphasis on conservation is necessary," and (2) that additional discoveries of copper at a significant rate will be necessary if the U.S. copper production rate is to be maintained until the end of the century.

The supply panel made four specific recommendations about fossil fuels and copper related to conservation, R. & D., and materials exploration, including the recovery of copper from manganese nodules from the oceans floors.

REPORT OF THE PANEL ON THE ENVIRONMENT

The panel on environment dealt with the case of coal, specifically with human health and safety, and with certain impacts on the ecological system as a whole. The panel concluded generally that pollution monitoring was inadequate and that funds for the study of environmental impacts of fossil fuels should be increased.

The panel made five recommendations dealing with miners' diseases, accidents, and accident prevention; and with the public health effects of sulfur pollutants from the burning of coal, including studies of sulfur, the redesign of protection standards and sampling systems, the immediate development and installation of sulfur oxide removal equipment in emitting operations, and the development of cleaner fuels.

REPORT OF THE PANEL ON DEMAND

The report of the demand panel challenged the credibility of existing materials demand projections and the assumption that they were not susceptible to change. The panel strongly emphasized the potential for influencing materials demand through market mechanisms, policy, and technology.

The panel reviewed the state of the art of materials demand forecasting and found that forecasting techniques were, in general, relatively primitive and needed improvement in terms of definition, aggregation, correlation with supply forecasts, and specification of data. The panel concluded that inadequacies in these respects had apparently created a tendency toward an upward bias in projections that exaggerated most materials demand estimates.

The demand panel's major conclusion was that efforts to increase supplies of fuel and minerals in order to close the gap between most existing demand and supply projections were misguided and would place an unnecessary hardship on the Nation. A policy that forced the Nation to undertake extremely rapid development of known energy sources in order to match demand projections, based on price trends that appear unrealistic for the future, could also generate the demand (for example, by keeping prices artificially low through subsidies) to use the supply. In this sense, demand projections could become self-fulfilling.

The other COMRATE panels found that supplies for the long run were limited; that technology could provide only limited solutions and involved long lead times; and that growth in the use of materials and energy was causing crucial environmental problems. The demand panel believed that policy should support social trends tending toward a lesser rate of consumption of energy and minerals, incorporate the long-term replacement costs of externalities involved in extraction and

use, and actively augment measures designed to curtail waste insofar as these cannot be efficiently handled by the price mechanism. Such a policy would be an essential anticipatory measure to prevent the disruptive adjustment processes likely to result from short-fall of materials supply. The demand panel made the following recommendations:

> Means should be taken to improve and require systematic collection and analysis of information, and to implement a more effective organization of government to make use of this information in order to anticipate contradictions between rates of use and supply.
>
> Greater technical ability should be developed to make better use of data and information in conditional and policy forecasting, particularly short- and medium-range. Important aspects would include consideration of alternative circumstances, policy options, and their direct and indirect social and economic effects.
>
> To the degree possible, policies to modify demand should be designed to function through the market mechanism rather than through direct governmental controls and allocations. Legislation and regulation should be designed so that supply prices fully reflect production costs. It should be required that energy-consuming products, such as buildings, automobiles, or appliances, carry when sold clear information as to their rates of consumption, efficiencies, and other pertinent information relating to operating costs.
>
> Compensatory programs and policies, and the necessary legislative and administrative basis, should be prepared and held in readiness to assist those particularly hurt by sudden transitions, particularly those arising from public policy.
>
> All elements of Federal legislation and regulation should be reexamined to assess their implicit effects on energy consumption.
>
> Through education, publicity, and example, those habits and attitudes sometimes called a "conservation ethic" should be encouraged.
>
> Restraint should be exercised in all-out efforts to increase supply to levels that could exceed requirements. (pp. 307–309)

Wilfred Malenbaum, of the University of Pennsylvania wrote a minority view to the panel report on the subject of materials demand. His criticism of the panel's report was that its conclusions were romantic rather than scientific and made no contribution to validly assessing minerals demand. Malenbaum challenged the panel's findings related to the need to constrain national growth on the basis that the panel's estimation of future demand-supply imbalances were based uncritically on the assumption of an increasing "intensity of use" of materials, which Malenbaum held may not in fact be the case. Malenbaum's points can perhaps be summed up by the following paragraph from his minority view section:

> Theory and history do offer important hypotheses on what makes for population growth, for national product growth, for materials use in product. The seeming conflict between a fixed stock and an expanding use has always been resolved.

Critical is not the number of man, the amount of material, but the imagination and skill with which man adopts the things he wants, the methods by which they are produced, the number of people that share them. The world needs social and economic progress. Only man with his limitless conceptual horizons, is able to balance these needs on a finite planet. Man is the most important world resource; the quality of man is at the core of the problems of balance in materials supply and demand. (p. 316)

—Summary by William C. Boesman.

XIX. IMPACT OF SHORTAGES OF PROCESSED MATERIALS ON PROGRAMS OF VITAL NATIONAL INTEREST

Summary of the Report to the Congress by the Comptroller General of the United States February 27, 1976 [1]

This report, by the Comptroller General of the United States, described the problems encountered by contractors due to the shortages of processed materials needed for programs of vital national interest. The General Accounting Office (GAO) report, which was performed pursuant to the Budget and Accounting Act of 1921 and the Accounting and Auditing Act of 1950, found that, during periods of shortages in processed materials, some Federal programs essential to the national interest have been delayed and could not obtain priority ratings because they did not qualify as "defense related" under clauses of the Defense Production Act. Accordingly, GAO recommended that 1) Congress consider legislation to amend the Defense Production Act to broaden application of the priority and allocation authority to include nondefense programs of vital national interest, and 2) that Congress consider authorizing a single agency to administer all priority programs.

IMPACT OF SHORTAGES

The GAO report concluded that because of insufficient producer capacity to handle upward surges in demand, government contractors had experienced an array of difficulties in obtaining a variety of materials. GAO noted that greatly lengthened lead-times, supplier allocation systems, and increased costs have had a major impact on government contractors. In response to the shortages situation during 1973 and 1974, GAO found that contractors had taken an array of management actions, at their own time and expense, to avoid missing target dates. GAO maintained "that many of the actions taken were basically good management practices which should have been taken earlier. The increased management attention given to material procurement should continue to minimize the effects of shortages."

Contractors noted that their actions were stopgap measures to meet the immediate impacts of supply shortages and that, in the event of long-range shortages, more positive action would be required to expand capacity.

PRIORITY SYSTEM FOR DEFENSE-RELATED MATERIALS

The report reviewed the priority system, resulting from the Defense Production Act of 1950, which allows the diversion of certain materials from the civilian sector for military uses. Title I of this law authorizes the President to establish priorities in the performance of contracts

[1] Comptroller General of the United States. Impact of shortages of processed materials on programs of vital national interest. Washington, General Accounting Office, 1976, 40 p.

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or orders necessary to promote the national defense and to require the acceptance and performance of such contracts or orders to insure such priorities. The law also authorizes the President to allocate materials and facilities to promote the national defense. These powers have since been delegated to the Federal Preparedness Agency (FPA) of the General Services Administration (GSA). Although the FPA has retained the final authority for determining which civil or civilian programs are "necessary or appropriate to promote the national defense", it routinely seeks the certification of the Department of De-Defense (DOD) before assigning such priorities. According to the GAO, DOD is considered by the FPA, to be the department with special competence to measure the impact on defense of a priority request. Consequently, a recommendation from the DOD is the essential ingredient in an FPA determination of whether to grant a request for priority assistance. GAO found problems inherent in this system. As they stated, "We believe there are situations, however, in which narrow interest can too readily influence DOD's discretion in this regard."

PRODUCTION CAPACITY

The GAO report warned that the improvement in the availability of materials in late 1974 could be misleading, since it was related to the Nation's economic recession, which had caused demand for materials to fall off rather than to increase production capacity. The mid-1974 demand levels had been higher than those in late 1974. GAO cautioned that government procurements and the economy of the Nation could be stifled without development of more production capacity, if demand were to exceed that of the recessionary levels of late 1974. GAO predicted that the delayed effects of shortages on the Federal Government programs will include lengthened procurement cycles and increased costs. GAO recommended that, for the government to cope with a recurrence of materials shortage problems, an identification of the current and future capability of industry to produce key processed materials is needed. Consideration should also be given to the effects of government regulations on production capacity and the possible use of incentives. The GAO opted not to make any recommendations on these matters, pending the completion of a study underway by the National Commission on Supplies and Shortages.

SUMMARY

The GAO maintained that the decision of whether to provide priority allocation of materials for "civil and civilian programs should depend upon a more independent and more balanced assessment of urgent needs." The GAO further suggested that the FPA should rely more on an independent analysis and less on the certification of the DOD in making its decisions to provide priority support. The GAO questioned whether demonstrable relevance to the military programs of the Nation should continue to be the only prerequisite for the provision of priority support for programs. To insure effective administration of a broadened priority system, the GAO recommended that:

1. Congress consider amending the Defense Production Act to broaden application of the priority and allocation authority to include nondefense programs of vital national interest; and

2. Congress, to prevent competition among the various priority programs, consider authorizing a single agency to administer all priority programs.

—Summary by Paul F. Rothberg.

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(Compiled by The Congressional Research Service for the use of the Joint Committee on Defense Production, June 1976)

The bibliography is arranged as follows:

I. Materials policy
II. Materials stockpiles
III. Materials accessibility on Federal lands
IV. Availability of materials (other than agricultural materials and water)
    A. Resource availability generally
    B. Industrial aspects
    C. International aspects
V. Availability of agricultural materials

References sometimes include information which overlaps two or more of the listed categories. When this occurs, the references are placed in the category which seems most appropriate. In a few cases, a reference to a specific section of a work has been placed in one category while reference to the entire work has been placed in another category.

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